SEPTEMBER 29, 1958

PRICE 50 CENTS

Product Engineering

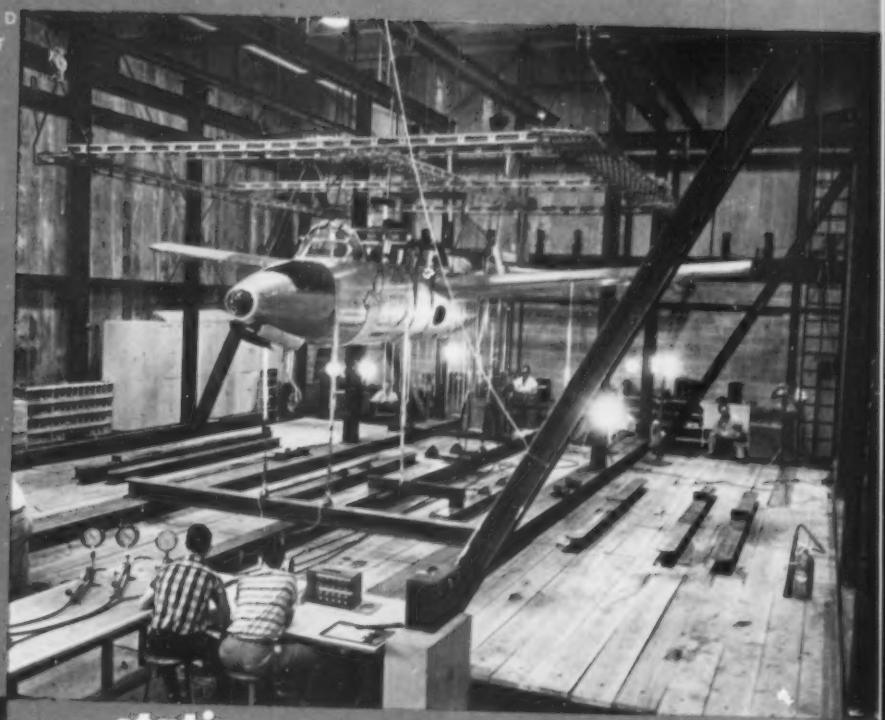
DESIGN edition

McGRAW-HILL MAGAZINE OF D
RESEARCH AND DEVELOPMENT

THREE NEW PLASTICS

TESTING...

see page 5



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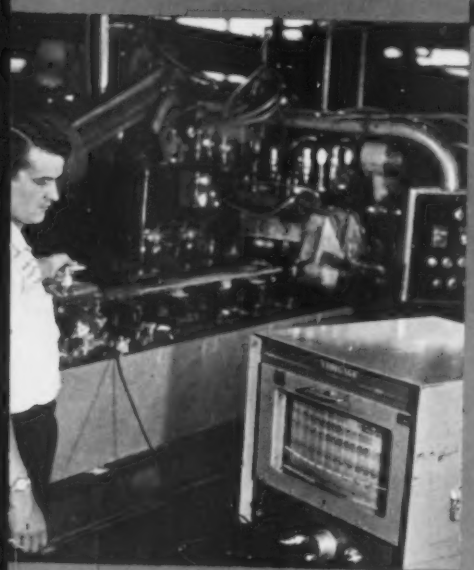

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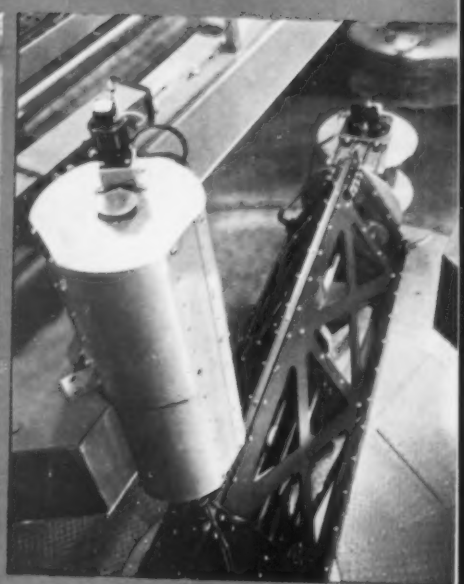

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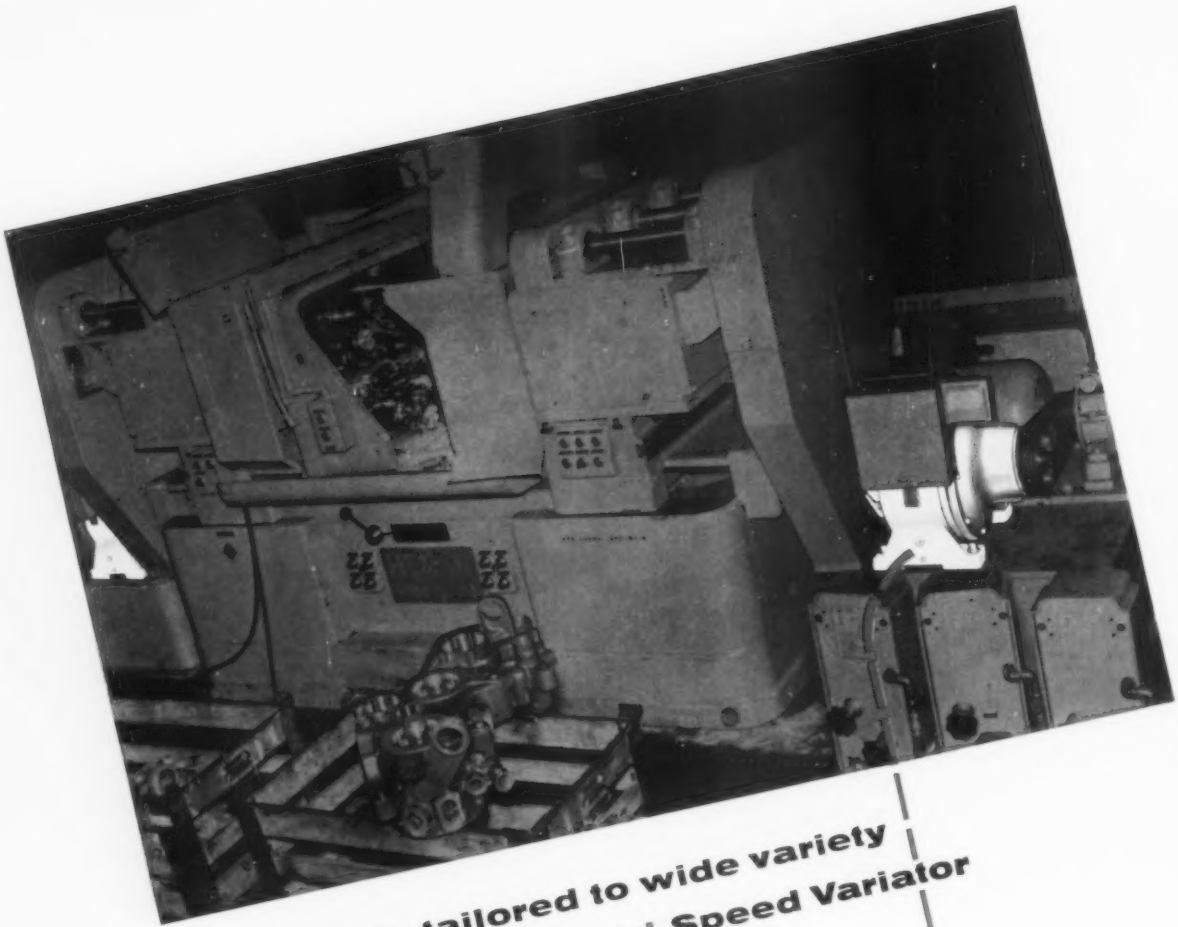


Machining speeds tailored to wide variety of metals with Cleveland Speed Variator

In the manufacture of aircraft engine components, Cleveland Speed Variators permit fast, accurate adjustment of machining speeds to the exact rpm required for various metals from magnesium to 38 Rc steel.

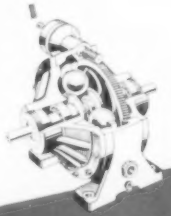
Infinitely variable, the Speed Variator provides continuous speed progressions over its full 9:1 range . . . from ⅓ to 3 times input speed. Manual or automatic remote control instantly and smoothly adjusts output speed. Variator is rugged, compact, quiet running.

For full details—photographs, sectional drawings, rating tables, specifications—write today for Bulletin K-200. The Cleveland Worm & Gear Company, Speed Variator Division, 3279 East 80th St., Cleveland 4, Ohio.

Sales representatives in all major industrial markets.
In Canada: Peacock Brothers Limited.

HOW IT WORKS

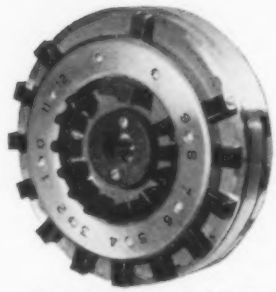
Power is transmitted from input shaft to output shaft through alloy steel driving balls which are in pressure contact with discs attached to the two shafts. Relative speeds of the shafts are adjusted by changing the positioning of the axles on which the balls rotate (see cutaway view, right).



CLEVELAND SPEED VARIATOR

PRODUCT-DESIGN MEMOS FROM DUREZ

Moisture-stable insulation | **Parts for the DC-8** | **Electric motor shortcut**



International Business Machines Corporation

Insulation-plus

A good example of what can be done with *Durez 16694* diallyl phthalate is this plastic-and-metal commutator for an electronic card sorter.

The commutator acts as a cam contact to establish the timing of impulses which energize a sort magnet. It incorporates a metallic hub, brass plate, copper ring, and 12 terminal inserts.

The molding material that holds these parts in place must:

1. Resist arcing.
2. Pass a 1000-volt dielectric breakdown test in high-temperature high-humidity conditions.
3. Retain high dimensional stability at 90°C and 90% relative humidity.
4. Possess wear characteristics that lead to maximum commutator and brush life.

Durez 16694 meets these requirements, and also provides critical dimensional accuracy between the terminals and the brass plate.

Its ability to do so suggests that you consider it for similar electrical jobs. It's the only type of plastic that retains high insulation values over extended periods at relative humidities above 90%. Its arc resistance, as measured by ASTM D495 (Method A or B) can be consistently reproduced. It does not corrode metal contact points, and is virtually free from cold flow and creep.

For a data sheet detailing properties of *Durez 16694* and of molded material, check the coupon.

Jet-propelled plastic

Streaking through the stratosphere nearly eight miles up, the Douglas DC-8 jetliner will bring new ease and convenience to air travel.

Passengers on the huge jet transport will relax in controlled climate provided by a system that changes cabin air every three minutes. Flight officers will scan their instruments by softly diffused light from a ceiling panel. In both instances, *Hetron*® 92 polyester will be helping to set the new pace in jet-age flight comfort. This Durez material, reinforced with fibrous glass, is specified for the DC-8's cabin ventilation ducts and cockpit light-diffuser panel.

Hetron 92 will also help to shade crewman's eyes against sun glare. The cockpit glare shield, above the plane's instrument panel, is made from glass-reinforced Hetron laminated with a core of cellular cellulose acetate.

Douglas uses Hetron also in the ailerons and wing-tip trailing edges of DC-6 and DC-7 series airliners, precursors of the DC-8. Hetron is specified because of its combination of strength and inherent fire retardance. It is permanently self-extinguishing without additives.

Douglas Aircraft Company, Inc.

There's a whole family of Hetron resins to give you the properties you need in structural parts—for an aileron or an outboard boat; for radomes or railroad cars; housings or heater ducts; fenders or fume hoods. To see how these self-extinguishing polyesters match up to your requirements, check the coupon for a complete Hetron data file.

Cost cutter

Looking for a lower-cost way to make an electric motor or generator? A commutator ring like this could be your answer.

Notice how snugly the metal contact rings fit the tough plastic base. It's almost impossible to pry them loose. Dirt or moisture can't get underneath to cause arcing, because the rings are molded in one solid component—not assembled.

You don't have to machine these commutator rings, either. They fit standard-size tubing—and fit it tightly so there's no vibration or motor noise.

These rugged rings are molded of *Durez 16771*, a high-impact glass-fiber-reinforced phenolic. This material stands heat up to 600°F. without distortion. Its dielectric strength, as measured by ASTM D149 (48 hours, 50% R.H., 23°C.) is 400 v/mil short time, 300 v/mil step by step.

If you see an opportunity in these rings, write to the molder, Norco Plastics, Inc., 3888 North Fratney St., Milwaukee 12, Wis. For data on the Durez compound with which they are made, just check the coupon.

For more information on Durez materials mentioned above, check here:

- ☐ Diallyl phthalate, 16694
- ☐ Hetron resins—technical data file
- ☐ High-impact phenolic, Durez 16771

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PLASTICS DIVISION
HOOKER CHEMICAL CORPORATION
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New steels are born at Armco

How special Armco Steels in vending machines help gain Balanced Design

High quality materials and *balanced design* are essential to long service life and trouble-free operation of vending machines. This is why Glascock Bros. Mfg. Co., Muncie, Indiana, manufacturer of a well-known pre-mix vendor, uses Armco Steels for many parts in their machines.

For example, parts that might be splashed by liquids are made of Armco ZINCGRIP® Steel (Bonderized and painted by Glascock Bros.). The special hot-dip zinc coating on the steel doesn't flake or peel . . . still protects the base metal against corrosion even if the paint is damaged.

To promote cleanliness, the cup-storage compartment is also made of Armco ZINCGRIP Steel. So are the covers for the coin mechanisms, as well as the baffle and outer shell for the refrigeration unit.

Armco Stainless Steel, Too

Parts that must withstand both corrosion and abrasion are made of Type 302 (Armco 18-8) Stainless Steel. And of course, all metal that comes into contact with the product is stainless, including the portable tanks.

For complete information on special Armco Steels that can help you give *your* products balanced design and new selling points, just write us at the address below. Our engineers will gladly consult with you on special problems. Armco Steel Corporation, 2808 Curtis Street, Middletown, Ohio.

ARMCO STEEL

Armco Division • Sheffield Division • The National Supply Company • Armco Drainage & Metal Products, Inc. • The Armco International Corporation • Union Wire Rope Corporation • Southwest Steel Products

Product Engineering

THE McGRAW-HILL MAGAZINE OF DESIGN, RESEARCH AND DEVELOPMENT

SEPTEMBER 29, 1958 Vol. 29, No. 40

Those Heavy Presses Can Pay Off 34... R W Smith, The RAND Corp
Admitted that the giant forging and extruding presses subsidized by the Air Force aren't kept busy. But are they "white elephants"? The author judges them by a novel way of estimating cost of heavy parts, and cites five new fields of work for the presses.

STAFF REPORT

*

Three New Rigid Thermoplastics 36... Ford R Park, Associate Editor
The technology of plastics has taken exciting new directions with 3 tough new resins—DuPont's Delrin acetal, GE's Lexan polycarbonate and Hercules Powder's Pro-fax polypropylene. In these curves and tables you'll see their importance and how they compare with each other and a standard nylon.

Design Features in New Products 42... This mechanical mule is lightweight—but muscular. Light metals were favored, air cooling further cut weight of the engine, and balloon tires eliminate all springing.

Tap the Reserve Strength in Metal 44... D J Graziano, Republic Aviation Corp
The need for streamlining and lighter-weight parts has been encouraging design engineers to go beyond the yield strength of a material. Here are the author's charts and formulas for determining how far you dare go—and a sample problem.

Safeguarding the Air Supply 48... E L Holbrook, Westinghouse Air Brake Co
In pneumatics, a breakdown will be less costly if emergency equipment is ready to step in. Here are 3 helpful setups; also how to make standby air do a non-emergency job—start up a gas turbine.

DESIGN FILE

Vibration Isolators: Zero Stiffness 52... A foreign digest
They provide a buffer between vibrating machinery and the surrounding structure.

A Look at Wire Inserts 55... H W Cram, Heli-Coil Corp
Roundup includes design features, diagrams and test results.

DEPARTMENTS

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New easier way

... to use stainless steel lock wire!

Note how the lock wire, uncoiling from the inside, is dispensed as needed from a hole in the top of this compact 1-pound package. No wild uncoiling! Moreover, the wire is better protected, handles easier and faster, with less waste, and with greater safety!

Here is a new National-Standard packaging development that is a natural for most safety lock wire uses in equipment manufacture, assembly and servicing.

For production operation requiring larger capacities, National-Standard offers lock wire on practical 5 and 10-pound disposable spools that may be spindle-mounted.

Check with National-Standard on the spooling of your choice and on stainless steel lock wire in any diameter from 0.020 to 0.067 and to government specifications: QQ-W-423, AN-W-24, MIL-W-6713 or AMS-5685-C.

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Interesting to Note . . .

Just Testing

Testing, that ingredient so vital to the success of all products, is portrayed in three different ways on our cover. One is a reliability static test taking place at the Dallas plant of Temco Aircraft Corp. Suspended on the stand is the new jet-trainer, TT-1 Pinto.

Another shows an ultrasonic testing device that measures the thickness of an object from one side without need to reach over physically to the other side. Here the Vidigage, an ultrasonic resonance gage made by Branson Instruments Inc, Stamford, Conn., is measuring an aluminum extruded section of a helicopter at Sikorsky Aircraft Div of United Aircraft Corp, Stratford, Conn.

Third method shows equipment at the Arma Division of the American Bosch Arma Corp, Hempstead, NY, where the Free World's greatest precision centrifuge is now operational. Exemplifying dynamic testing procedure, the Arma machine is housed within a 7-foot-high circular "silo." Besides determining accuracy of accelerometers, the centrifuge can also test equipment packages up to 300 lb. Forces exerted by the centrifuge upon an accelerometer during a test can range from one to 10 g's. Some equipment can be submitted to as high as 25 g's. Speed of the machine is so constant, acceleration can be detected to within 10 parts in a million. It was built and installed at a cost of $300,000 by Genisco, Inc., of California and took two years to complete the project.

Wrap It in Red Tape

Not too long ago, the Air Force insisted that all commanding officers, including those in high echelons, be pilots themselves. As "Perspectives" asks on page 31, why then should military R & D programs be controlled by nontechnical administrators who must depend upon specialized staff advice? One answer is: Military red tape has been around a long time. In fact the term" red tape" goes back over 200 years to when treaties, charters and official documents were tied with a red ribbon. Charles Dickens is credited with giving the term its present meaning. A friend asked him if he had seen a current government document. "No, I haven't," replied Dickens. "It's probably still being wrapped with all that red tape."

One of the best examples of "red tape" currently comes from an editorial in the Chicago *Daily Tribune*. It describes the runaround

(*Continued on page 7*)

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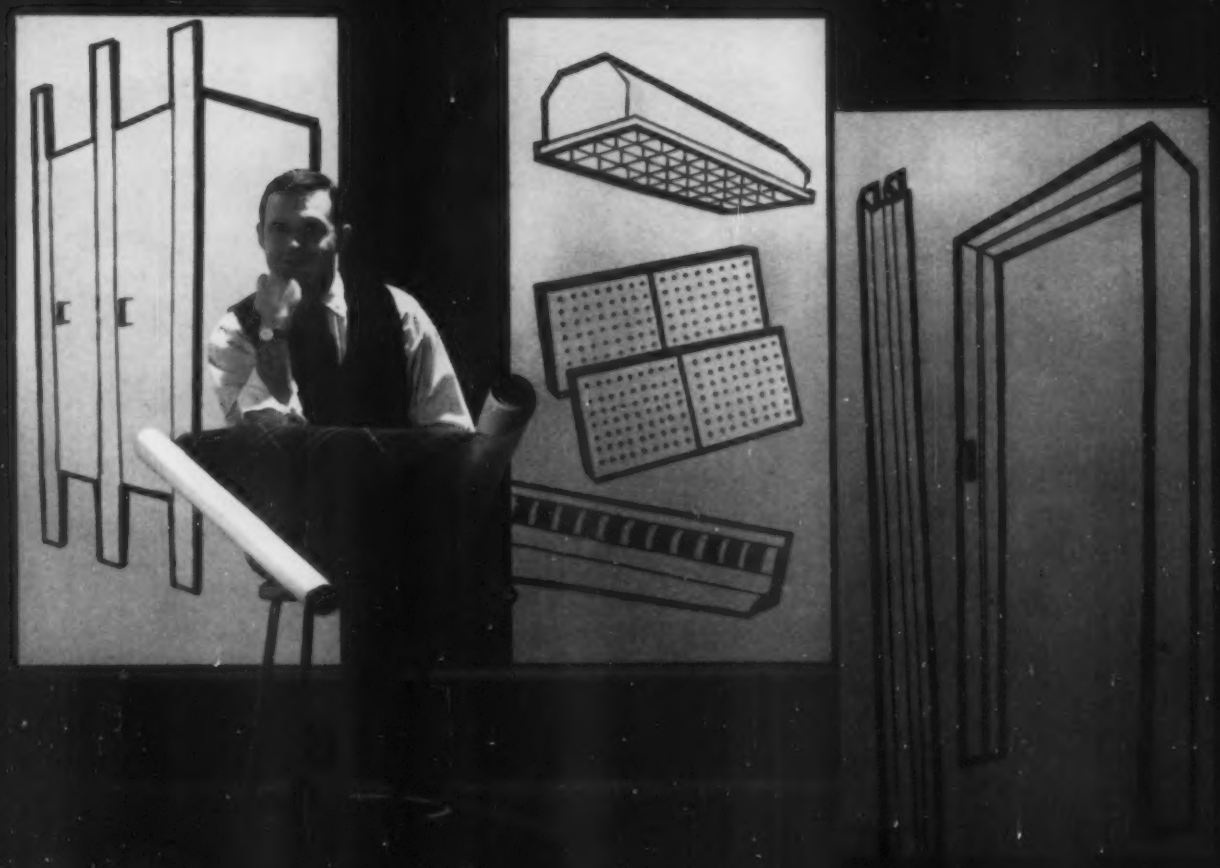

HOW ZINC-COATED STEEL SHEETS

KEEP PRODUCTS–AND MANUFACTURERS–LOOKING YOUNG

Today, it's almost axiomatic that the more zinc-coated steel you put to work for you, the more freedom your products will have from corrosion—and the more freedom you'll have from customer kicks about corrosion and corrosion-caused maintenance costs.

That's why it pays to use zinc-coated steel sheets in the products you manufacture (such as light troffers, metal ceiling tiles, baseboard heating panels, sliding door hardware, etc.).

Look at the formability, for example. With either electrolytically zinc-coated steel sheets, or continuous process zinc-coated sheets, the tight coating stays tight through the severest fabrication operations. How about corrosion prevention? It's long-lived, uniform, relentless. First cost is low. Maintenance costs are nil. And the results are a lasting credit to your product and your reputation. How about paintability? Electrolytic zinc-coated steel surfaces, chemically treated, are unexcelled for painted products. It lets paint dig in and hold its unbroken smoothness and beauty for keeps.

In electrolytically zinc-coated steel, the name that stands for bonus performance is Weirzin. In continuous process zinc-coated sheets, it's Weirkote. Let us show you how Weirzin or Weirkote will keep your products—and you—looking young.

Write for informative brochure on each today. Weirton Steel Company, Dept. D-24, Weirton, West Virginia.

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Interesting to Note . . . . *(continued)*

given Boeing Airplane Co when it sought the Army's advice on what interior dimensions would qualify the 707 as a troop carrier. Boeing was given a memorandum on the regulation size of railway tunnels. Here, Boeing also learned that the width of trucks and military tanks is based on Roman roads built 2000 years ago to accommodate a 4-horse chariot. And the memorandum added the scintilating fact that the Army's basic artillery piece, the 105mm howitzer, was originally designed according to the weight a team of six horses could pull.

Mechanical Mule

Recently the Navy's giant carrier Enterprise passed on at the mature age of 20. Though she was still in her prime, as capital ships go, her usefulness in today's Navy was at an end–so the hero of the Pacific was junked. After all, what can be done with such tons upon tons of war equipment when a war has ended? In 1945, many companies were asking themselves this question and another one related to it: "What peaceful machines can be made with our present tools and dies?" If you were a company manufacturing tanks or land mines, the problem was complex; for Willys-Overland, it was easy–make more Jeeps.

Some changes had to be made before the military Jeep could become commercial. Alterations were required of the gear ratios in the transmission, transfer case and axles, permitting a tractor-like pull at low speeds; a gear ratio had to be provided that would allow Jeep speeds up to 60 mph. It also needed a new combustion chamber, better radiator and new steering equipment. When this was done the Jeep, like so many GI's, took off its dog tag and put on civies.

Since returning to civilian life the Jeep has grown, and even started a family. Its newest offspring is the "mechanical mule" (p. 42) which, like its predecessor, is starting its career in the Army.

Plastics for the Dogs

When horse racing became limited in some states it was decided to spur the gambling urge by devising other attractions. Pitting a tortoise against a hare was obviously unsuccessful when a New Orleans entrepreneur found that the hare never heard of Aesop and neglected to take a nap in the backstretch. However, tortoises are being employed in Florida and the Virgin Islands as racers. Numbers are painted on their shells, bets are taken and about half a dozen of the amphibians are placed in a pool. First to swim to the other end wins.

Dogs have long been a favorite of the gambling set. Greyhound racing was originated by the Egyptions and antedates horse racing by 1000 years. It was, however, only a fad. Since bearbaiting, dog fighting, snake-mongoose matches *et al* have been outlawed it was only natural that dog races would again come into popularity. Unfortunately for the dogs, running around a track after an illusive mechanical rabbit violates the natural movements of the dog's bones and muscles. When making a turn at either end of the oval track, the dog's right hind foot exerts tremendous upward pressure. This pressure, pushing against the full weight of the dog, can displace or break the delicate scaphoid bone. About half the dogs that injure themselves in this fashion never run again–some have to be killed.

For some time doctors have tried to devise an artificial scaphoid bone for greyhounds. Stainless steel was tried but found too heavy. Then an Englishman, J. K. Bateman, tried a small block of acrylic plastic to replace the scaphoid in the leg of a greyhound named Hare Spy. The operation was successful and one of the commonest causes of greyhound injury can now be helped with plastics.

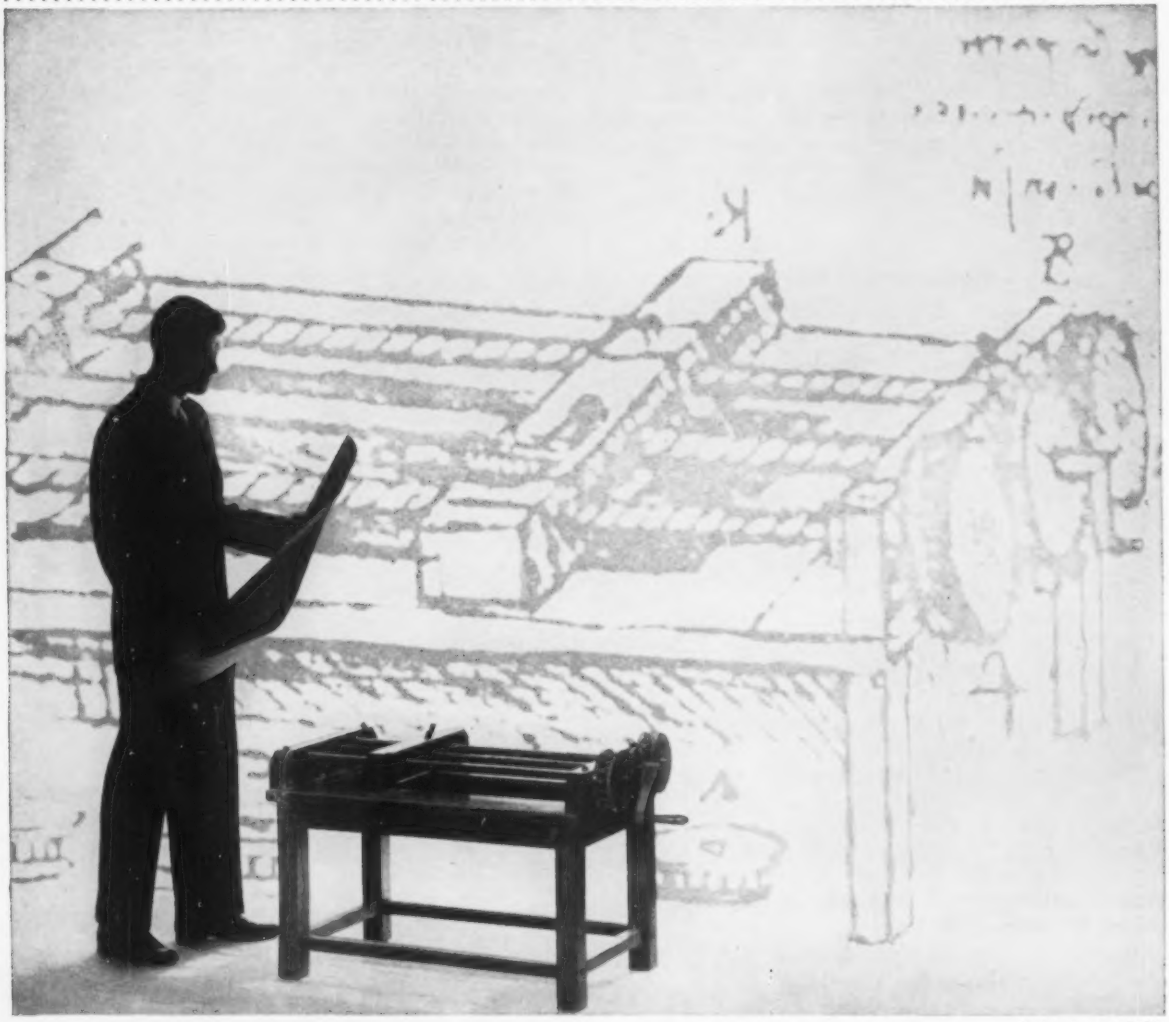
In the growing field of plastics, three new tough, rigid thermoplastics have recently been introduced. On page 36 appears a comparison of these, containing much unpublished data assembled by the Editors.

Get the Air Out

There are many men of science who have earned their reputation as a result of a simple dramatic experiment or invention while the rest of their scientific discoveries are overlooked. Eli Whitney is remembered for his cotton gin, yet few know him as the originator of our present-day mass-production methods; Robert Hooke is known for his treatise on stress and strain, but it's been forgotten that he had first suggested the theories of gravitation–which Newton then polished and published. Few books on science credit Otto von Guericke with having constructed and made public the first electrical machine, in 1660. Instead, every physics book contains the story of his famous Magdeburg sphere. Here, air was evacuated from two hemispheres placed together and 16 horses could not separate them.

Aside from this dramatic demonstration of a vacuum, von Guericke should also be remembered for his invention of the air pump. In 1654, this Burgomaster of Magdeburg took a copper cylinder and fitted it with a piston whose head was packed with hemp to make it airtight. He then had a score of men try to hold the piston at the top of the cylinder while he exhausted air from a stopcock at the cylinder's base. This experiment led to his principles on suction and finally to the design of the first air pump. It was several hundred years later that air valves, pumps and compressors were truly harnessed as an industrial power source. Safeguarding this power supply is the subject of the article appearing on page 48. —Benedict A. Leerburger, Jr

creative designing calls for an open mind



Leonardo Da Vinci's design for a screw cutting machine

Model courtesy of IBM

EVEN THIS DA VINCI DESIGN COULD HAVE BEEN BETTER WITH HELP FROM AN SKF ENGINEER.

The kind of bearings your SKF engineer recommends depends solely on your requirements, not on what he has to offer. That's because the SKF line includes all four basic types of ball and roller bearings in many thousands of sizes. This gives him the kind of flexibility he needs to keep an open mind on any bearing problem. Give your problem to SKF and see. 7832

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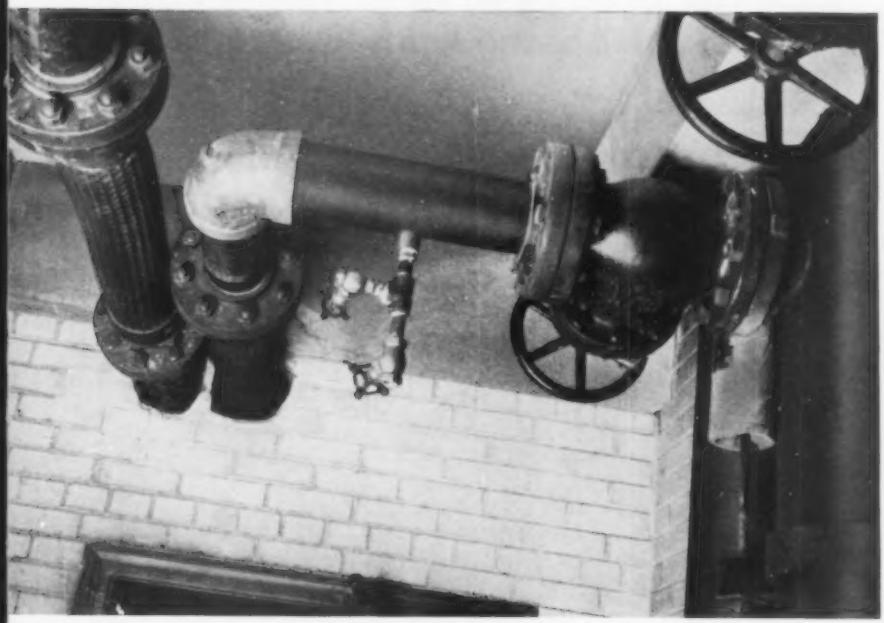
APPLICATION HINTS:

Ways to simplify construction and cut costs with Flexpipe



Flexpipe helps meet tough piping problem in air conditioning an existing building

THE PROBLEM: Air conditioning an existing office building usually calls for a bit of ingenuity in design. One large New York office building decided to air condition by making provision for packaged, water-cooled units to be installed on any floor as tenants required.

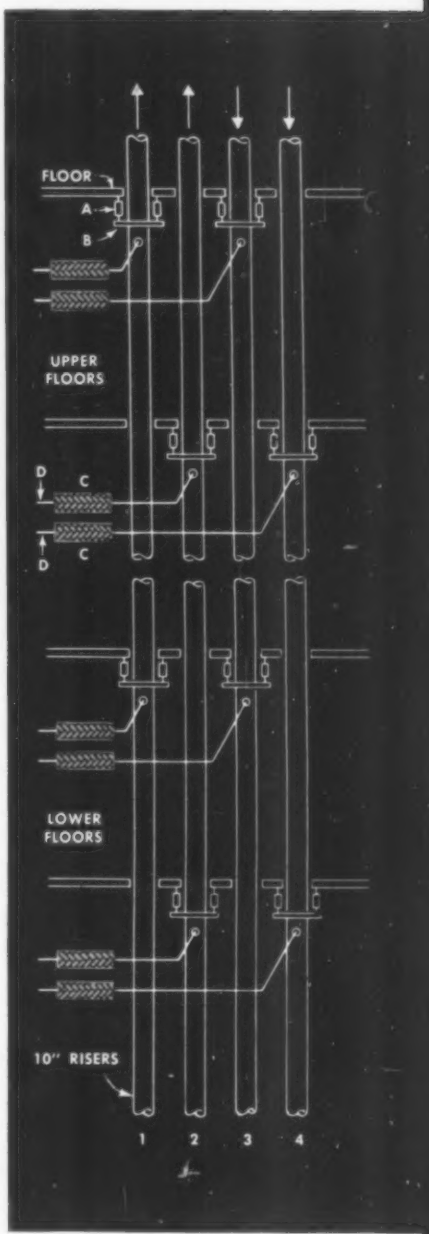
This called for four 10-inch risers, running the height of the building, to carry cooling water between the cooling tower and the branch pipes at each floor level. Because of structural conditions, the risers could not be run down through the basements and supported from below. The combined weight of pipes and the water was so great that they could not be anchored at any one point on the structure.

So the consulting engineers, Zimmermann Engineering, New York, floated the risers on spring hangers, distributing the weight evenly over all floors. This meant, however, that the risers were free to move. A riser full of water weighs several tons more than an empty one and settles about two inches.

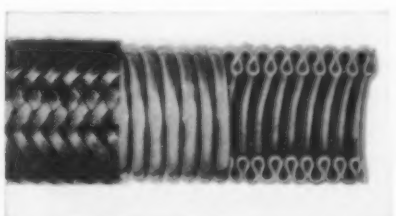
Therefore connections between risers and branch pipes had to be flexible. They also had to have strength, because water pressure at the lower floors approaches 400 psi.

THE SOLUTION: Flexpipe connectors were the answer. They provided the flexibility and the strength required. Furthermore, they were available in the sizes needed —from 5" diameter at the lower floors to 2" at the top floors.

WHERE TO BUY: Flexpipe connectors come in convenient standard sizes and are sold by leading distributors. They can show you samples and answer questions about service applications. For the name and address of the one serving your area, or for more detailed information, write to: The American Brass Company, American Metal Hose Division, Waterbury 20, Conn. In Canada: Anaconda American Brass Limited, New Toronto, Ont.



SCHEMATIC DIAGRAM showing how cooling-water risers were installed. A: spring hangers. B: pipe clamps. C: Flexpipes. D: branch pipes at each floor. 1, 2, 3, and 4: risers, 10 inches in diameter. *Upper left:* Photo of Flexpipe installation at a lower floor.



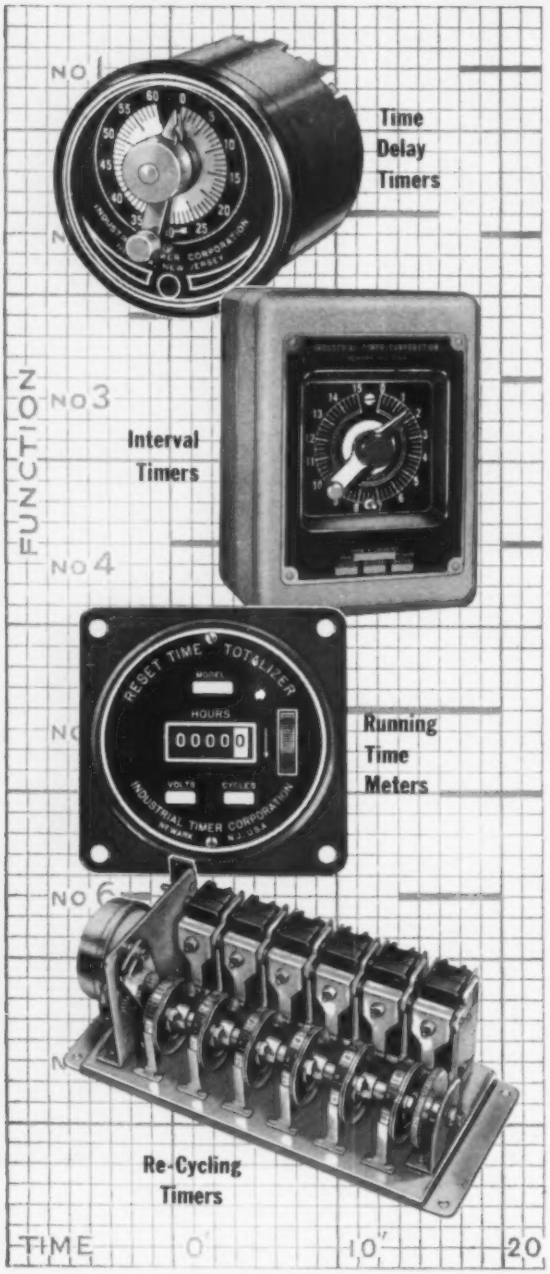
FLEXPIPE'S flexible core can be either tin bronze, hot dipped galvanized steel or stainless steel. End fittings (attached): flanges, threaded males and welding nipples.

Flexpipe® an **ANACONDA®** product

made by The American Metal Hose Division of The American Brass Company

CIRCLE 106 READER SERVICE CARD

Need a "SPECIAL" TIMER ...need a "STANDARD"?



Here's why WE can give you the fastest service

When you want a timer, you want one that fits your needs 100% — and you want it *fast*. Get in touch with Industrial and you'll get both. Because:

In our 20 years of experience, we have developed over a *thousand combinations* from our **20** basic types, to meet the widely varying needs of our customers. Therefore — many jobs that would seem to require a "special" timer are in fact a "standard" timer with us. Here is one tremendous saving of time for you.

When you *do* need a special timer, this same wealth of experience goes to work for you at once to design it. Our Engineering Department not only originates new designs, but also develops modifications for that purpose. That's why requests for special timers can be filled without delay.

Each method — designing for a standard timer or for a special timer — has its advantages. Designing for an already available timer means lower costs, faster service, simplified replacements.

Designing for a special timer has its advantages too. It means you'll fulfill your needs 100% — no need to limit your designing horizons. Either way — standard or special — you'll get the timer you want most promptly from Industrial.

Or perhaps you need quick service on timers for automatic controls. Here too Industrial Timer is your first source of supply. For in this field Industrial has a big head start. True, each automatic control job is a bit different from the rest. But the record shows that our years of timer experience has given us the special knowledge it takes to give you the right answers in near-record time.

So, for the utmost in all-round timer service, it's Industrial that offers you this outstanding combination: deliveries "Immediate on Standards . . . First on Specials." Plus the experience of one of the foremost group of timer engineers in the nation.

Timers that Control the Pulse Beat of Industry

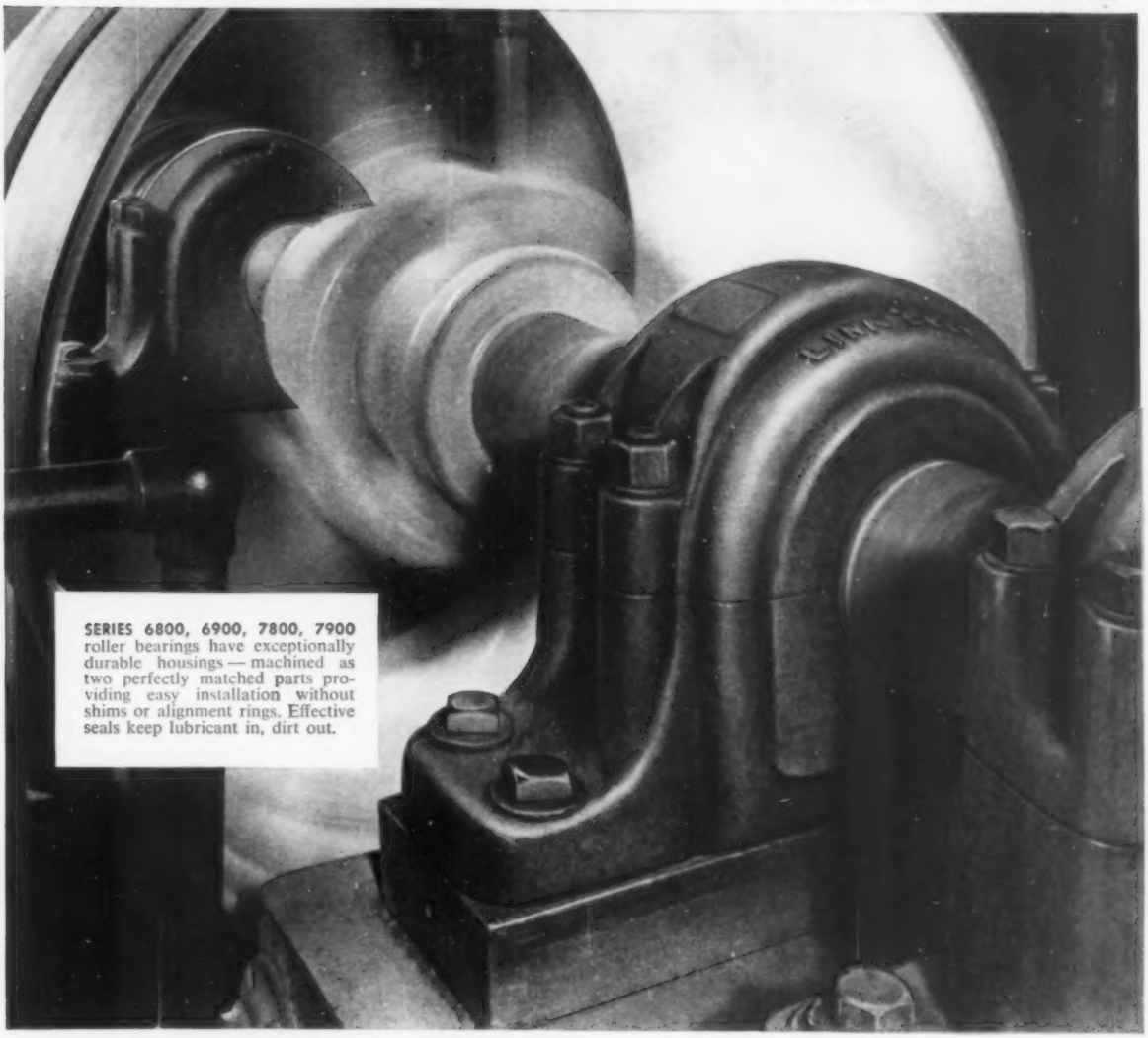
INDUSTRIAL TIMER CORPORATION

INDUSTRIAL TIMER CORPORATION

1415 McCARTER HIGHWAY, NEWARK 4, N. J.

AFFILIATE—LINE ELECTRIC COMPANY

NO PINCH, NO BIND-- ALWAYS-ALIGNED

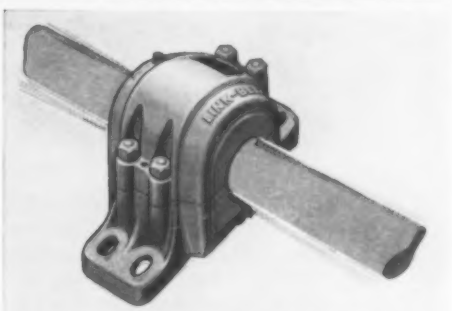


SERIES 6800, 6900, 7800, 7900 roller bearings have exceptionally durable housings — machined as two perfectly matched parts providing easy installation without shims or alignment rings. Effective seals keep lubricant in, dirt out.

These husky bearings in husky housings adjust *instantly* to shaft misalignment

Shaft deflection often means quick failure for ordinary bearings . . . but not for these rugged Link-Belt *self-aligning* bearings. Adjusting immediately in any direction, they easily compensate for misalignment . . . avoid damaging "pinch" and bind.

You can get full information on Link-Belt's complete bearing line from any one of 40 Link-Belt offices.



Spherical bearings are free to align in any direction, assuring full load capacity regardless of shaft deflection.

LINK-BELT

MANUFACTURERS OF SELF-ALIGNING BALL AND ROLLER BEARINGS

LINK-BELT COMPANY: Executive Offices, Prudential Plaza, Chicago 1. To Serve Industry There Are Link-Belt Plants, Sales Offices, Stock Carrying Factory Branch Stores and Distributors in All Principal Cities. Export Office, New York 7; Australia, Marrickville (Sydney); Brazil, Sao Paulo; Canada, Scarboro (Toronto 13); South Africa, Springs. Representatives Throughout the World. 14.95-A

A Report on the

Ten basic attributes that can help you satisfy both design and production needs.

The properties of copper alloys are a handbook in themselves. No group of metals is more versatile. Here are electrical, thermal, structural, chemical and finish properties that are unique. Here are metals that can be shaped and joined by almost every known method.

There are over 40 standard alloys of copper. And each has its own set of specifications, its own combination of properties. Finding the one that best matches *your* specifications is the problem. And the answers to that problem keep changing. Copper industry research into new alloys and new forming and preforming methods gives designers a latitude today that challenges both their imagination and their ability to keep posted. Today we must assume that some copper alloy *can* do the job.

Here are just ten of the more important design requirements that point to the selection of a copper alloy:

1.

Electrical Conductivity. The various types of commercially pure copper have long been the most economic conductors. Now, copper-chromium and copper-cadmium alloys have improved mechanical properties along with high conductivity. And silver-bearing coppers with as good conductivity as commercially pure copper have a higher softening temperature for certain applications involving high temperatures.

2.

Thermal Conductivity. Since many of the low-zinc brasses, as well as copper itself, offer outstanding heat transfer rates, selection usually depends on the other properties desired – corrosion resistance, hot strength, ductility, etc.

3.

Corrosion Resistance. Every corrosion problem is different – and there's a copper alloy to meet most: for chemical applications, heat exchangers, processing equipment, refrigeration apparatus, etc.

4.

Strength. The high-zinc brasses, nickel silvers, beryllium copper, the silicon bronzes and the phosphor bronzes can be processed to provide tensile strengths of the order of 140,000 psi for hard-drawn wire.

Copper Metals

5.

Ductility. The ductility of most copper alloys permits forming them into a wide variety of shapes and sizes, by spinning, stamping, deep-drawing, etc. For example, the coppers, most brasses and nickel silvers are ideal for cold forming.

6.

Malleability. Pure copper and many of its alloys have excellent malleability for forging, cold heading, coining, embossing, extruding, knurling, swaging, etc.

7.

Machinability. Free-Cutting Brass, tellurium copper, some of the bronzes and the leaded brasses are readily machinable at high speeds and feeds.

8.

Joining Qualities. Copper and most copper alloys can be easily soldered — or, for even stronger joints, brazed with either silver alloys or copper phosphorus alloy. The non-leaded brasses, phosphor bronzes, silicon bronzes and cupro-nickels as well as deoxidized copper also lend themselves readily to welding by a number of processes.

9.

Surface Qualities. The nickel silvers and low-zinc brasses are widely used in ornamental applications because of their ease of plating and finishing as well as their cold-working properties. New fine-grain brasses offer an ideal surface structure for high finish.

10.

Casting Facility. There are eight basic categories of casting alloys, ranging from the hard, but very strong, manganese bronzes to the free-machining leaded bronzes.

The combination of properties that you need for the best product and the optimum manufacturing cost can probably be found among the copper metals. The copper industry will help you find it. The Copper & Brass Research Association, 420 Lexington Avenue, New York 17, New York, will welcome your inquiry.

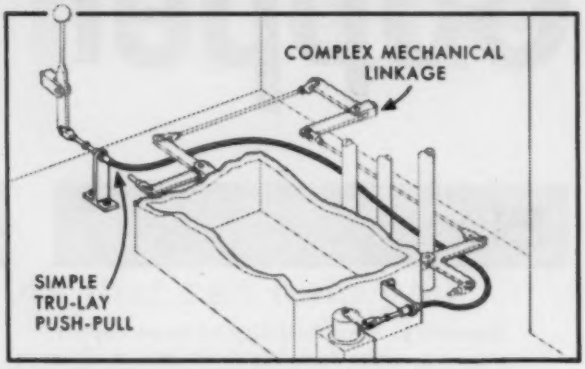
There's a new frontier in...

COPPER
BRASS
BRONZE

with TRU-LAY PUSH-PULL controls, you can---

MAKE HUNDREDS OF PRODUCTS MORE USEFUL, EASIER TO SELL

Tru-Lay Push-Pull controls provide positive remote action over long or short distances. Because they operate while flexing, they can snake around obstructions. They are ruggedly constructed, easily installed and operated, and are sealed against dirt and moisture. Push-Pulls are simple, have but one moving part, are noiseless, and give a lifetime of accuracy. Linkages, on the other hand, are complex. They're made of many parts, wear at many points, and produce increased backlash, lost accuracy, and vibration rattles.



Here's Why Push-Pull Controls Simplify Design, Give Better Performance

Long Life—We have never heard of a Tru-Lay Push-Pull wearing out in normal service.

Dependable Operation—Top performance under the most adverse conditions...in temperatures ranging from –70°F to the high levels of jet engine operation...in wet locations...in abrasive atmospheres.

Freedom from Trouble—Inner working member is fully protected by tough, flexible conduit...lifetime factory lubrication...sealed against entrance of dirt, moisture, and other foreign matter...cold swaging of all fittings.

Accuracy—Built to the most exact standards of quality and precision. On automobile pushbutton transmissions, for instance, Push-Pull controls provide five positions with a total movement of only .560".

Capacity—Push-Pull controls will handle jobs with as much as 1,000 lbs. input, 150 feet or more from the control point.

Adaptability—Push-Pull controls can be adapted to countless applications. Standard anchorages, fittings, and heads meet almost any requirement, and modifications can be made to fit special situations.

Design Engineers Report on Benefits

Saves Time, Labor, and Material
"We use Push-Pulls to operate clutch controls on the main power unit, feed conveyors, and delivery conveyors...and we save the time, labor, and material required for planning and engineering the old linkages."

Greater Flexibility of Design
"Push-Pulls give us flexibility in locating the hydraulic control valve in relation to the operator's position."

Cost Less to Install
"They are easier and less expensive to install than linkages for remote control of power take-off."

Solution to Tough Problem
"Can be installed where straight rods are impossible."

Eliminates Maintenance
"No maintenance whatsoever; not even lubrication is required."

Reduces Number of Parts
"Your Push-Pulls have eliminated links, radius rods, and other lost-motion devices for remote control of hydraulic valves."

Provide Accurate Control
"We get minimum backlash because the cable is designed to close tolerances with minimum drag and lost motion."

Push-Pulls Can Help Solve YOUR Remote Control Problems

Push-Pull controls are solid as a rod and flexible as a wire rope. You can use them in the electrical, hydraulic, and pneumatic systems on construction equipment, on farm implements...almost *anywhere* convenient remote control is desired. For complete details on how you can use them, write for a copy of the Push-Pull Data File. It contains 7 bulletins which describe in detail the operation of Push-Pulls, their applications, features, and advantages. Our engineers will be glad to help you make Tru-Lay Push-Pull controls a part of your product.

Automotive and Aircraft Division
AMERICAN CHAIN & CABLE

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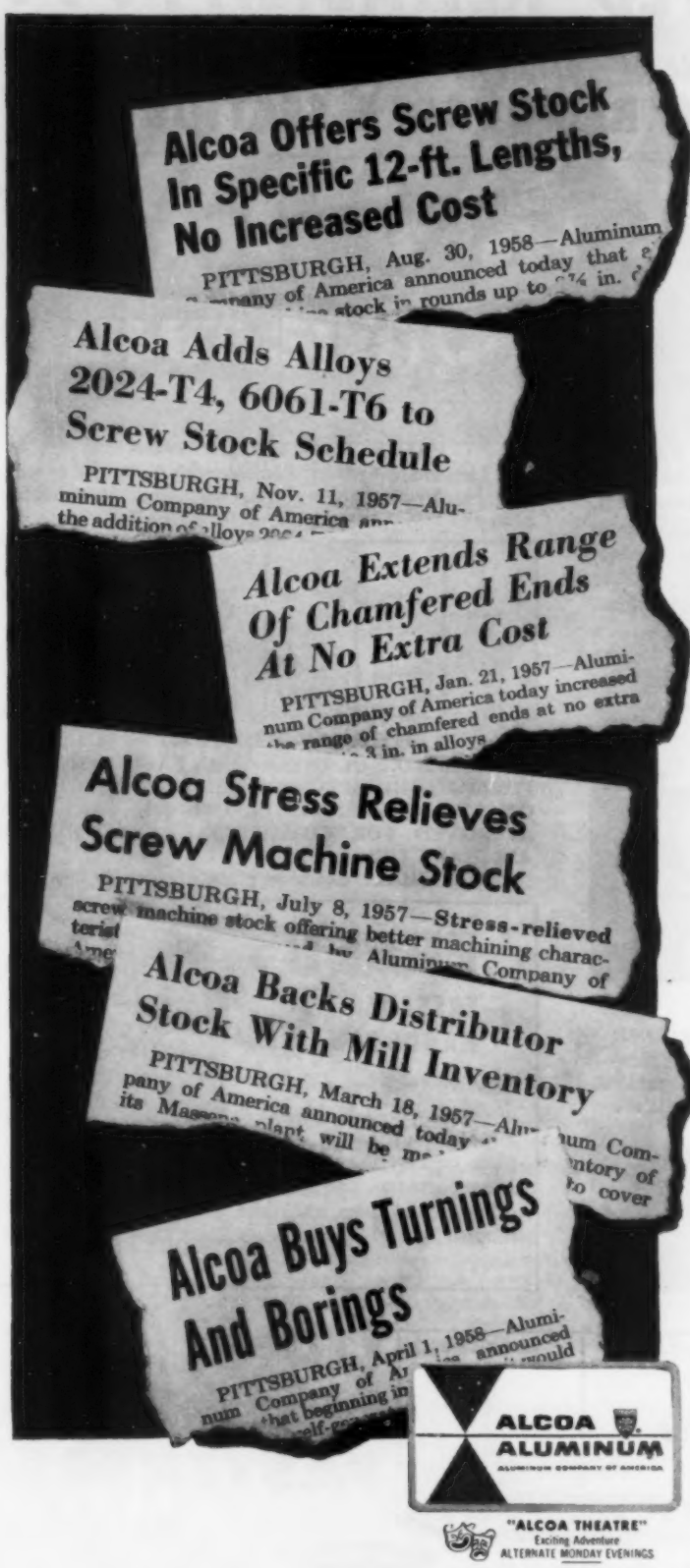
ACCO

DESIGN FREEDOM STARTS WITH ALCOA ALUMINUM


Alcoa Offers Screw Stock In Specific 12-ft. Lengths, No Increased Cost
PITTSBURGH, Aug. 30, 1958—Aluminum
Alcoa Adds Alloys 2024-T4, 6061-T6 to Screw Stock Schedule
PITTSBURGH, Nov. 11, 1957—Aluminum Company of America
Alcoa Extends Range Of Chamfered Ends At No Extra Cost
PITTSBURGH, Jan. 21, 1957—Aluminum Company of America today increased
Alcoa Stress Relieves Screw Machine Stock
PITTSBURGH, July 8, 1957—Stress-relieved
Alcoa Backs Distributor Stock With Mill Inventory
PITTSBURGH, March 18, 1957—Alu
Alcoa Buys Turnings And Borings
PITTSBURGH, April 1, 1958—Alumi
ALCOA
ALUMINUM
"ALCOA THEATRE"
Exciting Adventure
ALTERNATE MONDAY EVENINGS

THE BIG NEWS IN SCREW MACHINE STOCK COMES FROM ALCOA

We think there's more to service than making the best screw machine stock readily available in any quantity. ALCOA is consistently a step ahead with new economies, new design and production conveniences. Here are six ALCOA "firsts":

- Specific 12-ft lengths at no extra cost—all screw stock in rounds to 2⅞ in. dia. and hexagons to 2 in. across flats.
- Alloys 2024-T4 and 6061-T6 added to Screw Stock schedule. This means important economies through the addition of sizes formerly nonstandard which are now standard and groupable for price advantage.
- Chamfered ends at no extra cost for all rounds and hexagons up to 3 in. in alloys 2011-T3, -T8, 2017-T4, 2024-T4, 6061-T6.
- Full screw stock size range of alloys 2017-T4, 2024-T4, 6061-T6 stress relieved for improved machining characteristics.
- Mill inventory to supplement distributor stock and cover emergency requirements of mill customers.
- ALCOA agrees to purchase up to 60 per cent of customer's turnings and borings generated from alloys 2011-T3, 2017-T4, 2024-T4 and 6061-T6.

These and other reasons have prompted designers and production engineers of leading industries to switch to ALCOA® Aluminum Screw Machine Stock. The whole story, with direct quotes, is in three new ALCOA booklets—yours for the asking. Use the coupon.

Aluminum Company of America
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Please send your case-history booklets containing quotes from leaders in industry on why they buy from Alcoa.

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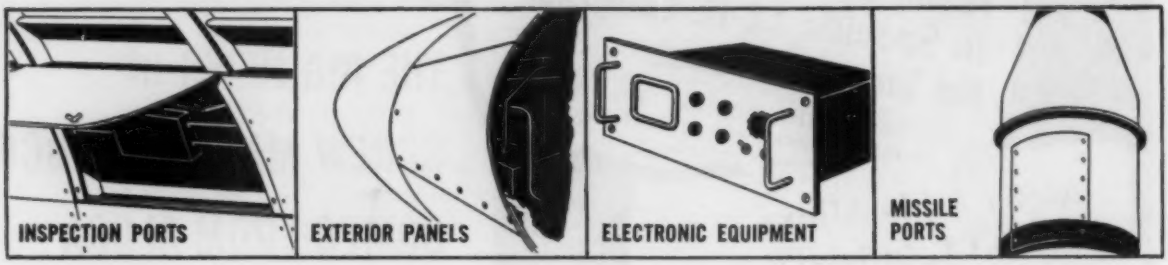
FLIGHT-PROVED RELIABILITY . . .

LION *Quarter-turn* FASTENERS FOR SECURING REMOVABLE SECTIONS



Southco's Lion Quarter-turn Fasteners provide quick access and reliable securing of hinged or completely removable panels. Resistance to severe heat, shock and vibration, and a high strength-weight ratio make these unique fasteners ideal for use in private, commercial or military aircraft and missiles . . . for ground production and control or airborne applications.

Lion Fasteners consist of three parts . . . a one-piece, swaged-nose stud; a retainer; a floating receptacle which is riveted or welded in place. Installation requires no special tools . . . is simplified by a permissible float of .070".

SWAGED NOSE

Case hardened one-piece stud with swaged nose has no milled sections, inserts, or cross pins . . . requires no wire spring to hold it in locked position. Lion Fasteners offer the highest weight-strength ratio available.

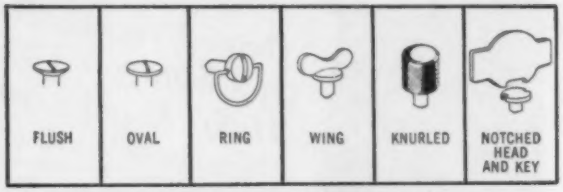
2 TYPES AVAILABLE

LION NO. 2 FASTENER
For use where space is limited and where weight must be kept at a minimum.

LION NO. 5 FASTENER
For heavy-duty applications where good tensile and shear strength are required.

FULL RANGE OF HEADS

Lion No. 2 Fastener available with flush, oval or wing type. No. 5 with flush, oval, ring, wing, knurled or notched head and key.



OTHER SPECIFICATIONS

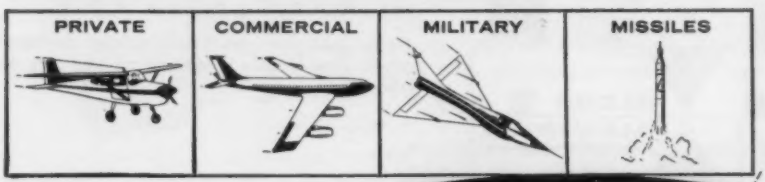
LION NO. 5 QUARTER-TURN FASTENERS CONFORM TO MIL. SPEC. MIL-F-5591A (ASG) . . . ARE ON THE GOVERNMENT'S QPL . . . ARE CAA APPROVED FOR COMMERCIAL AND PRIVATE AIRCRAFT USE.

MATERIAL: Cadmium-plated case-hardened steel.

FREE!

FASTENER HANDBOOK

Send for your free copy of Southco Fastener Handbook No. 8. Gives complete engineering data on Lion Fasteners and many other special fasteners. Write to Southco Division, South Chester Corporation, 236 Industrial Highway, Lester, Pa.



LION *Aviation* FASTENERS

one of the SOUTHCO FASTENERS LION

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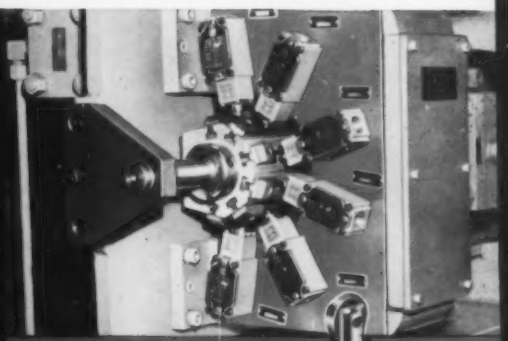
ALLEN-BRADLEY

BULLETIN 802T

OILTIGHT

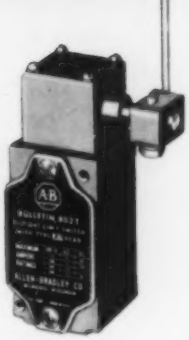
LIMIT SWITCHES



Radial mounting of six Allen-Bradley "manifold" type, push roller, oiltight limit switches.

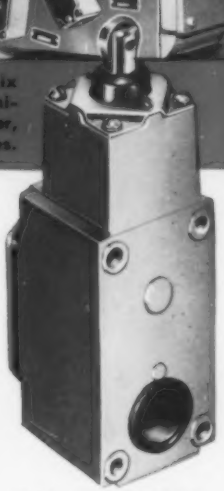
SIDE PUSH ROD

FORK LEVER TYPE

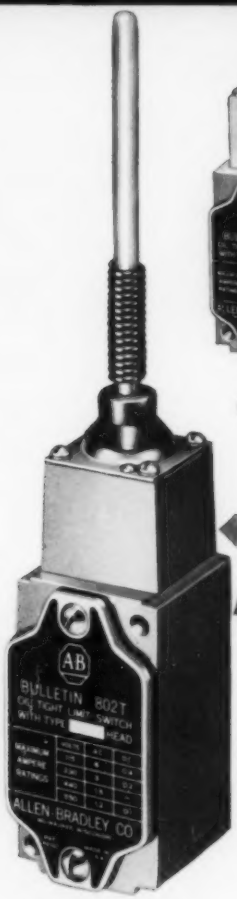


ADJUSTABLE ROD

TOP PUSH ROD WITH PLASTIC WINDOW



Push roller, oiltight limit switch, showing rubber grommeted wiring hole on back of "manifold" type, used on above automatic production machine made by Cross Company, Detroit.



WOBBLE STICK TYPE

OIL SEALED HEAD AND BODY

assure reliable operation

Completely sealed . . . oil, dirt, and metal chips cannot foul up contacts or operating mechanism. Operating heads are interchangeable—can be mounted in any one of four positions. New "wobble stick" heads operate in any direction. All of these limit switches have maintenance free, double break, silver alloy contacts. Specify Allen-Bradley—the *quality* line of limit switches.

ROLLER LEVER FOR CAVITY MOUNTING

ADJUSTABLE ROLLER LEVER

A-B QUALITY

ALLEN-BRADLEY

MOTOR CONTROL

QUALITY

Allen-Bradley Co., 1316 S. Second St., Milwaukee 4, Wis.
In Canada: Allen-Bradley Canada Ltd., Galt, Ont.

9-58-R

THE ONLY LINE OF

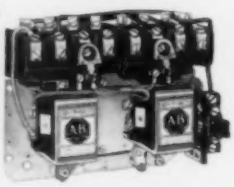
D. C.
MOTOR STARTERS
with modern
SOLENOID CONTACTORS

With Allen-Bradley, you get D. C. motor control that is *completely modern!* It uses the simplest switching mechanism yet conceived . . . the solenoid contactor with only ONE moving part. There are no bearings to stick . . . no jumpers to break. This assures millions of trouble free operations. And the double break, silver alloy contacts never need maintenance. Available in ratings up through Size 4. Write for details.

CONTACTORS

Bulletin 202 solenoid type contactor. In ratings to 150 amp. Also, clapper type to 600 amperes.

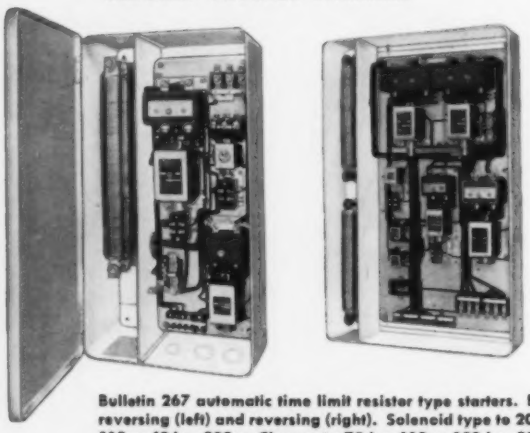
FULL VOLTAGE STARTERS



Bulletin 205 full voltage reversing starter. Ratings to 1½ hp, 115 v; 2 hp, 230 v.

Bulletin 209 full voltage starter. Available in ratings up to 1½ hp, 115 v; 2 hp, 230 v.

REDUCED VOLTAGE STARTERS



Bulletin 267 automatic time limit resistor type starters. Non-reversing (left) and reversing (right). Solenoid type to 20 hp, 115 v; 40 hp, 230 v. Clapper to 75 hp, 115 v; 150 hp, 230 v.

9-58-MR

ALLEN-BRADLEY
MOTOR CONTROL
QUALITY

MAIN OFFICE and Factory
1316 S. Second St.
Milwaukee 4, Wis.

In Canada: Allen-Bradley Canada Ltd., Galt, Ontario

DEVELOPMENTS TO WATCH...

Simplified computer circuits . . .

. . . that require only magnetic cores and connecting wire (no diodes, tubes, or resistors) to perform logic operations ("and", "or", negation, etc.) at high speed have been developed at Stanford Research Institute.

Key to the development is "geometric variation of the basic magnetic core toroidal structure" that makes it possible, by proper interconnection of core elements, to "provide unilateral information-flow properties without the use of explicit unilateral devices such as diodes." SRI calls the new components *Multi-Aperture Devices* (MAD), and points out that they are still in the laboratory stage; but says their use in shift-registers, at least, is "approaching commercial feasibility."

Are the brakes being applied . . .

. . . to increasing compression ratios in automotive engines? If they aren't, they should be, say oil-company engineers. At the last SAE meeting, for instance, a California Research Corp group said the octane number of today's premium gasoline is already "at or somewhat beyond the most economical point for present-day commercial processes." Noting the increasing severity of troubles with knock, ping, and rumble (PE—Aug. 4, p 19) as compression ratios rise, H. F. Hostetler and W. R. Tuuri of Standard Oil of Ohio's Automotive Engineering Div said flatly, "Higher compression ratios may increase nothing but customer complaints."

Auto industry leaders also recognize this problem in engine design; and it's likely that the rate of increase in octane number, which has been about one point a year, may be little more than half as great from now on.

New engine governor . . .

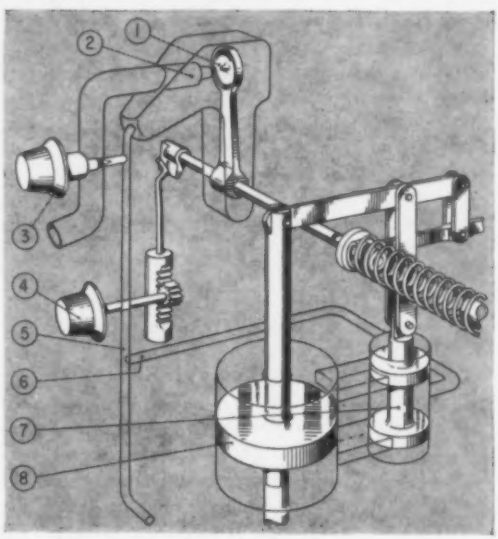
. . . designed in England features an unusually simple mechanism which responds rapidly to speed changes. Basically, it's a spring-biased scoop against which the engine pumps a jet of hydraulic fluid. The scoop is connected, by a simple mechanical linkage, to a load-limitation control. The faster the engine runs, the stronger is the jet force on the scoop.

Engineers at Bryce Berger Ltd who designed the unit point out the only mechanical connection to the engine is the speed-control linkage (a remote gear pump provides the drive), and engine fuel also serves as hydraulic medium. Moreover, this system, unlike orifice devices, is almost completely insensitive to temperature changes.

A number of arrangements are possible to adapt the unit to various types of engines. The diagram here shows fluid-flow path of a setup designed for a large propulsion engine: Scoop (1) is actuated by jet from nozzle (2) and is connected by series of linkages to a load-limitation control knob (not shown). Duct (5) connects the scoop chamber with an accumulator (not shown), which provides the constant back-pressure needed.

Duct (6) connects the accumulator to the spool-type servovalve (7), which, in turn, is connected to the output piston (8).

A bypass valve, operated by speed-selection knob (3) is provided to control the amount of fluid reaching the jet nozzle, so that when the flow of fluid to the jet nozzle is reduced, the engine must run faster to maintain the same pressure on the scoop.



Knob (4) operates an assembly that makes it possible to control the percentage drop in engine speed (and consequently the reduction in jet thrust) as the load on the engine is increased any given amount. This provides for stable operation.

DEVELOPMENTS TO WATCH...

Radiation-activated light sources . . .

. . . have reached the prototype stage at U. S. Radium. These are tube-type devices in which a radioactive gas (tritium), sealed inside a glass tube, is used to activate a phosphor. They provide continuous lighting without any electrical connections and are expected to have a service life of 10 to 25 yr.

First application is to be in markers for aircraft; but instrument lighting is also under study.

(For more information on this type of light source, see *PE*—Dec. 16, '57, p 5; and for a full-scale report on another new type of lighting, electroluminescence, see *PE*—*Sept. 15*, p 74).

As anticorrosive coatings for metal parts . . .

. . . the Navy's Bureau of Ships is testing resin-fiber surfacing materials. One- or two-ply overlays of glass or synthetic fiber fabric, impregnated with polyester or epoxy resins, applied to metal struts, shafts, and rudders, are now undergoing ship trials. First reports indicate they'll do surprisingly well if properly bonded, and merit further study for parts difficult to protect by conventional means.

New motor-starting switch . . .

. . . encapsulated to prevent the contamination that frequently results in faulting, will be featured in a line of single-phase motors soon to be unveiled by A O Smith Corp. Switch has "self-cleaning" scissor action at switch points; and the entire mechanism, including actuator, capacitor, thermostat, and terminal panel is encased in the protective aluminum "capsule." More information in next issue.

Chilled-water, fan-coil systems offer . . .

. . . a low-cost route to central air conditioning, says W. S. Harris, Research Professor at the U of Illinois.

Reporting on a three-year test of such systems, he figures a well-insulated, six-to-eight-room, two-story house can be kept cool for less than 80¢ a day if the proper control system is used. This applies, of course, to his or a comparable climate, and assumes a power cost of 2½¢/kwh. Three types were tested:

1. Fans in fan-coil units ran continuously, while the circulation pump and chiller were controlled by a room thermostat.

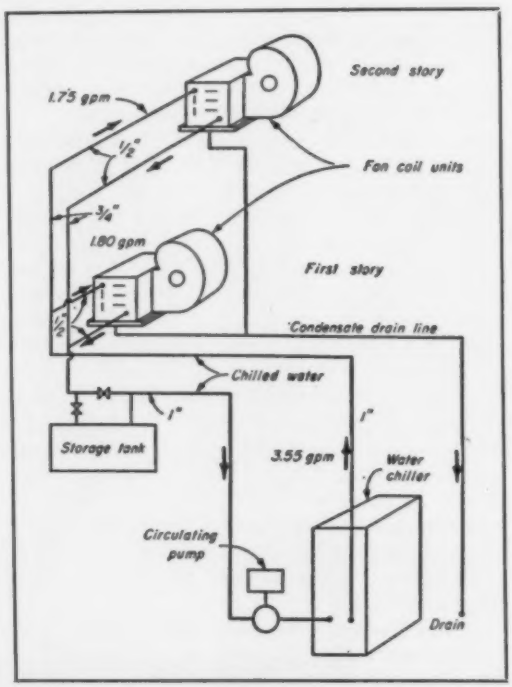
2. Circulating pump ran continuously, while chiller and fans were controlled by the thermostat.

3. Pump ran continuously; chiller was controlled by a thermostat responsive to the temperature of the water entering the chiller; and fans ran continuously, but bypass dampers were provided so fans could circulate room air around coils during off-periods.

Fan-coil units were smallest available, rated at 10,000 btu/hr, with an entering water temperature of 45 F; flow rate, 2.5 gpm; and entering air at 75-F dry bulb and 63-F wet bulb temperature. Chiller was rated at 18,400 btu/hr with an ambient air temperature of 100-F and a flow rate of 4.8 gpm of water.

Of the three systems, the second seems best. The third was most costly to operate, and the first tended to create a condition of high humidity.

Tests are continuing but a 32-page interim report may be had from I-B-R Research, 801 W Green St, Urbana, Ill. Price: 50¢. —ARG



Home air conditioning system is diagrammed here. Illinois Engineering Experiment Station estimates installation cost at $1400, using commercial components.

US Must Up R & D Pace—Gavin

Effective research and development and new product programs are required if the US is to stay ahead of Russia, says former head of Army R & D.

. . . experience and vision of people."

CAMBRIDGE, MASS—"Russia can mobilize its entire effort to any particular commodity and undersell the free world in the open market," said Lt. Gen. James M. Gavin in an exclusive interview with PRODUCT ENGINEERING. Formerly head of the Army's Research Program, he is now vice-president of Arthur D. Little, Inc., a Boston industrial research and consulting firm.

"An example of this effort," Gen. Gavin added, "is the recent aluminum situation when Russia unloaded tons of the material on the world market pushing the cost down 2¢ a pound. She could drive any industry out of business by this method.

"To be able to stay ahead of Russia in the future, we must use all the technical facilities available, making the most effective use of our research and development programs, and keep far enough ahead of Russia in the development of new products that she won't be able to compete with us, no matter what her methods may be."

Stressing the importance of vision in people heading up R & D programs, General Gavin also said that Russia does not necessarily have plans to fire a rocket to the moon. Such a decision is one of the biggest strategic decisions made today. Gavin's other comments:

• What makes a development program successful?

"The essential ingredients of a good R & D program are the experience and vision of the people heading it up: enough experience to keep abreast of developments in their area and then enough vision to project the experience into the future to anticipate technical trends. Money can't buy this; nor can organization charts, big labs and nice buildings. So it comes down to the right man. Of course the right man without resources can't do much either, but the resources can be bought. We do not lack people with imagination.

"Research can get lost when it is about six echelons under a vice president who is also concerned with personnel and budgets. Research needs its own vice president reporting to top management."

• How does the new Defense Act affect R & D?

"This Act centralizes research under the Department of Defense, which seems like a good idea. However, it may get too highly centralized, depending on how various research divisions are integrated. It could be done very well indeed. But it could be restrictive in the lower echelons where you have specialists. Take the nuclear submarine, for example: the dedication of one man carried it through despite obstacles. I wonder whether it could have been done under a highly centralized research organization of several echelons."

• How are our satellite, missile and nuclear power programs doing?

"Things are moving along reasonably well. Cessation of nuclear tests will have some impact on tactical weapons. The tests were on fundamentally defensive weapons, including air defense, and were important. It took a while to get public support of the tests.

"I've been associated with the satellite and big missile program for some time. The record is clear that we did not get the support in our satellite program that it deserved three or four years ago. But by scraping here and there we managed to keep enough technical competence so that when the situation developed last October we were able to get a satellite up quickly when we were given the authority. But for this, we still wouldn't have a satellite. You cannot replace the sense of personal dedication and compulsion of a man on the firing line. I think that is true of most research."

• What are the problems of a military research program?

"In some ways military research is different from a non-military program. Civilian research is product improvement, profit motivated; whereas military research is essentially creative and looking for a new product the forces in the field need.

"The budgeting cycle in the Dept. of Defense calls for a year-to-year way of doing business which no research group likes. Each project must be justified each year, and this means some feast and famine. You might get lots of money one year but the next administration doesn't like a project and drops it. Or, you just can't get enough money and you tend to do more than you should but still accept a little slippage and a later date in getting what you're trying to get. These things are not at all common to business."

• Does officer rotation affect the efficiency of research?

"The system has its advantages. You will find a number of young colonels with their doctorates now in research in the Pentagon. Eventually they will go to a missile command in the field to use this equipment and see its problems in combat. Their next tour of duty will be back in research at perhaps a different echelon, or, at a business school, and then back into research. This works out quite well if you have a good pool of research-oriented types. I would prefer this to having an officer spend his military life at one research lab.

"If all the people should stay at

"Essential ingredients are . . .

one place for a career, it would give us a sad top management in time. We don't send young men to West Point, Annapolis or the Air Academy to make second lieutenants or ensigns out of them. We've demonstrated that we can do this any time during an emergency in 90 days. We train a man to have the growth potential to match the requirements of national leadership. This means a man who can represent the US in SACEUR (Supreme Allied Command of Europe). This job has many research, procurement, production and political problems. Or, it might be the command of the Continental Air Defense Command. The Chief of Staff today makes some tough R & D decisions.

"Frequently civilians in the Pentagon come in contact with this rotation system and find to their surprise a half-a-dozen or so competent majors and colonels in their outer office. Then they want to keep these men forever.

"In the last war I was told by the commander of the first nuclear bomb that there was pressure on him to take people right out of research laboratories around Cambridge and make them admirals. This makes a lot of sense to civilians; it's a job rating. But to the military it's just another job."

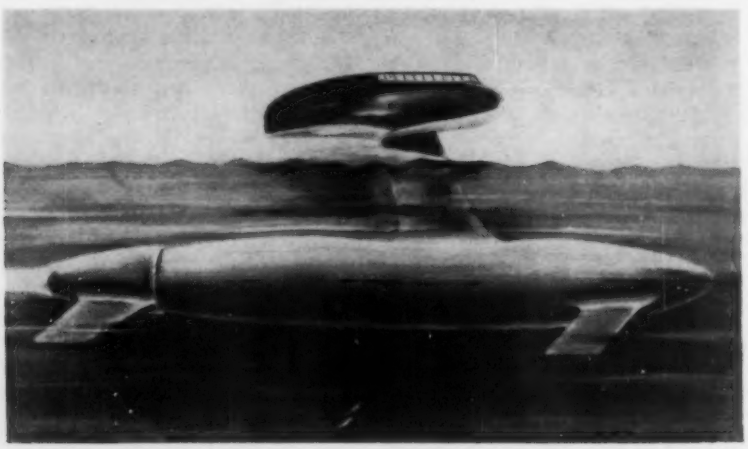
• What is Russia's strong point in research?

"It is more highly centralized than ours and Russia is quite arbitrary in making decisions. The country is limitless in its resources that can be applied to a task. The people are unstinting in their support of what they consider top priority. The incentive program that we are so proud of as capitalists, Russia has really used as a tool, and terrifically so. When they wanted a nuclear weapon, they got it by putting a man in charge of it who could get it—I think Beria was in charge. He was a tough guy who didn't know an atom from an ashcan, but he got the nuclear weapon. Every national resource was put behind him."

• What is Russia's interest in a rocket to the moon?

"Why should the Russians beat us to the moon? This is a very interesting point. Do they want to go there? Maybe when we get to the moon we will be very surprised to find that Russia had no intention of going there at all. The amount of resources put into such a program represent one of the biggest strategic decisions being made today. Considering the economy of our country and the cost of weapons systems and the psychology in the battle for men's minds in which we are now engaged, if the Russians make the right decisions for the next 5 or 10 years, they may not have to fire a shot—and they realize this.

"I don't know that they will want to go to the moon. They might bypass it, or just treat it as an incidental project—a by-product of going to Mars. They might lead us to believe that it is very important to go to the moon and then pay no attention to it. This would be very clever strategy if it were sound. It may be good to go to the moon rather than some other place or maybe it is a logical stepping stone in the exploration of space. I'm inclined to believe the latter. But the big decision is, how much do we want to pay for this diversion?"



Underwater cargo vessel . . .

Aerojet-General Corp.'s Underwater Engine Div. has a feasibility contract to design this jet-propelled craft (PE, Aug. 18, '58, p. 23). Attached to the cargo submarine by a thin strut is a gondola-shaped structure to house crew and navigation equipment. Sub will travel 100 ft below surface, will be 500 ft long with a 47-ft beam and travel at 35 knots. Use of nuclear power is planned.

Power Station On the Moon

BALTIMORE, MD.—If and when we get to the moon, Westinghouse Electric has come up with a way to set up a power station using the sun's energy. Basic components of the station are a wire mesh and large sheets of a thin plastic material coated with a thin layer of a photo sensitive material. The wire mesh is insulated from the plastic and picks up the electrons emitted by the coated plastic sheet. Total weight of the material would be 3 lb./kw.

A factor in the operation of such a power supply is that a vacuum must exist as in a tube. This condition is present on the moon. A roadblock to the practical generation of photoelectric power is the internal impedance of the unit. Formerly, photoelectric cells had internal impedances of about one megohm. Work at Westinghouse has produced cells with impedances of 3000 ohms and new cells in near future, says Westinghouse, indicate impedances of only 0.1 ohm.

Design All-floated Gimbal Rate Gyro

PHONIX, ARIZ—Completely floated rate gyroscopes capable of withstanding 150 g shock or acceleration have been developed by Garret Corp's AiResearch Mfg. Div here. Weighing less than a pound, the 210 series gyros have completely floated gimbals. Damping is held nearly constant with an ambient operating range of 67F to 165F by silicone oil flotation, plus a variable gap ring and cam design instead of vibration-prone rate springs.

Operation is from dc or cps ac single or three-phase 350 to 2500.

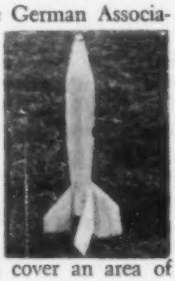
Bits and Pieces

Battery anyone? . . . will be the big question if drivers of the 1959 GM cars can't get the engine to turn over. A fluid coupling in the Hydramatic transmission has been removed, preventing the car from being started by a push from a helpful motorist.

Another diesel car . . . will be added to the Daimler-Benz line. The new model will be the 190D with a slight increase in price over the 180D, which will be continued. The 190D will have a 58-hp engine with a displacement of 1897 cc, giving a max torque of 83.25 ft-lb at 2200 rpm. Fuel consumption is 35 mpg. The non-diesel 220S will be available with a fuel injection system, formerly limited to the 300 series. Increased in horsepower from 120 to 130 to give 9% increase in acceleration.

An envelope of air . . . between a ship's hull and the water is the answer to reducing the friction between the two according to reports from a Danish shipbuilding firm. The air film is maintained by pumps forcing air through fine jets on the hull below the water line. The air is skimmed off the hull as it nears the stern, to avoid erosion on the propellers. Increased speed is possible; also, the air film prevents marine encrustation on hull surface.

Oil for rough seas . . . via a rocket is being tested by the German Association of Rocket Engineers. The rocket (right) will carry 35 oz of oil 330 yards. The oil is then released to calm rough waves to facilitate life saving operations. The oil will cover an area of 100,000 sq ft.



A wingless, research flight vehicle . . . equipped with double rotors is being developed by Chrysler Corp and the Army Transportation Corps for non-combat missions. The unit, powered by a 350-hp, 6-cyl, aircooled engine, carries a 1000-lb max load. Air streams, directed through vanes, control lift and direction of the craft.

Inspection by X-ray television . . . Heating element terminals and thermostat assembly of an electronic frying pan are inspected from the screen of GE's TV X-ray image intensification system which is 10,000 times brighter than fluoroscopic images. Right, the assembly of spring, ball and plunger in a plastic atomizer.

Develop Super-bright X-Ray TV

MILWAUKEE—The X-ray Department of General Electric has developed a TV X-ray image intensification system, which displays an image on a television-type screen 10,000 times brighter than on a conventional fluoroscope. Bright enough for easy viewing in normally lighted areas, the viewing monitor also magnifies the image size electronically up to 3 times actual size without greatly affecting resolution.

The system also permits the addition of monitors which can be placed up to 1400 ft away. This system permits the safe use of any x-ray intensity needed for penetration.

Consisting of three basic units—the x-ray sensitive camera, the control unit and the viewing monitor—the system can be used with any standard x-ray generating apparatus and materials handling equipment.

Camera consists of an x-ray image pickup tube, horizontal and vertical sweep subchassis and preamplifier subchassis. All are contained in one cabinet. The camera tube allows direct transfer of x-ray energy to electron energy capable of being displayed on a TV monitor and eliminates three energy conversions which formerly contributed to to a high noise level.

The control unit is contained in a metal cabinet shown under the monitor with its 12-in. picture tube. Horizontal resolution is 46 lines per in at center of the picture tube; vertical resolution is 37 lines per in. Input power at 115v 60 cycle is: camera 55 watts, control 305 watts, monitor 170 watts.

Medaris Says Missile Designers Need New Training

DETROIT—Missiles and space vehicles have opened new opportunities for research and development, but require a new kind of training for the engineers that design and test the vehicles and their components, Maj. Gen. John B. Medaris said at the American Rocket Society meeting here.

As much as 70% of all work connected with space vehicles and missiles is in research, development and design, generally involving the joint efforts of research institutions and industry. This high ratio of R & D to production is evidence of the limited knowledge on which designs are based, and of the speed with which new knowledge is obtained to form the foundation of more advanced and ambitious design.

In certain limited areas, however, production of components is in sufficient numbers to make them more nearly industrial products, i.e., recording and telemetering equipment, launching and other ground-based accessories, and some power units.

The building-block concept is already accepted. An engine with an estimated thrust of 1,500,000 lb, now in development at Rocketdyne Div of North American Aviation, may be completed within a year by joining together in a cluster a number of rocket engines already tested and operational. Development of a single-chamber rocket engine of equivalent capability is expected to take five years. When developed, it probably will be used in clusters as the first stage of larger vehicles.

URGENCY OF SPACE PROGRAM

Speaker after speaker frankly pointed out the competitive nature of the space program. Meeting almost exactly a year after Sputnik I, the American Rocket Society was given a sober appraisal of Russian achievements and capabilities. Richard Cesaro, of the Advanced Research Project Agency, discounted the possibility that the Russian earth satellites were achieved by concentrated effort in this field at the expense of research in others.

Lt. Gen. Arthur G. Trudeau, chief, R & D Dept. of the Army, commented: "I would like to see our lead time in R & D reduced. Since World War II, our lead time has been on the order of 8 or 10 years. This is unacceptable in the face of Soviet lead time of about 5 years."

THE FIELD FOR ENGINEERS

Speakers said that engineering technology in the field of space travel is

> "Impact of space age on industry is not expected to be overwhelming in terms of quantity production or mass employment over the next few years. But, as hardware for missiles and space vehicles has to be designed to tolerances and reliability of a completely new order, the design concepts involved and the techniques developed to translate these designs into hardware are sure to be adopted in other than the space field. In this sense the space age carries further the process of technical refinement of the previous ages."
>
> Homer A. Boushey, B/G USAF
> Director of Advanced Technology
> HQS, USAF

> "To keep its vitality, a civilzation needs a distant goal to which it can bend its effots. Space flight is ambitious enough to spur us to the needed break-throughs in science and technology, yet is near enough to keep our enthusiasm from flagging."
>
> K. J. Bossart, Asst. to VP,
> Engineering,
> Convair, Div., General Dynamics

Electra becomes a Buick . . . new type of suspension in 1959 Buick models like this Electra 2-door hardtop, is combination of air springs in rear and coil springs in front. Positive traction differential automatically delivers power to the rear wheel with most traction during heavy ice and snow driving conditions. Glass area in this model is up 67%, from 1,047 sq in to 1748 sq in. Standard in the Electra and Invicta series is the 401 cu in Wildcat 445 engine that gives 445 ft/lb of torque. It has 10.5—1 compression ratio, and a 4-barrel carburetor. Buick has dropped names of Special, Century, Roadmaster and Limited for the lower-priced Le Sabre, the medium-priced Invicta and the luxury model Electra.

Rambler custom sedan . . . has a 2-piece die-cast grille, a starter button combined with a neutral button on the automatic transmission system panel and a new carburetor for the 127 hp six to up its fuel economy by 1½ mpg. Vertical hairline down the center of the grille indicates where sections are joined. This design simplifies assembly in addition to reducing repair costs when one side of the grille is damaged. To further protect against this, both front and rear steel bumpers are 23% heavier than previously for greater strength and brake linings on the six and Rebel V-8 have been increased in thickness to 7/32 in. giving a 30% increase in lining life. The Rambler Six horsepower is up to 138. The valve system on the Rebel V-8 215 hp engine has been redesigned for quieter operation.

Traditional luxury styling . . . GM's 1959 Cadillac coupe is equipped with newly designed shock absorbers that automatically compensate for variations in operating temperatures to increase absorber efficiency. Model also features cruise control which permits driver selection of speed, no manual operation of accelerator; cruise control can be cancelled out by depressing either the brake, or the cruise control selector knob as well as by turning the knob to neutral position on hydramatic selection panel.

still too undeveloped to form the basis of a new branch of engineering. But the education of our engineers tends to be too specialized and perhaps not sufficiently based on fundamentals. As a result, almost all engineers recruited to the space program go through a period of "cross-training", in which they are given a more thorough indoctrination in engineering disciplines other than their own.

The heads of the space program urged engineering schools to produce graduates with a comprehensive engineering foundation, strong on fundamentals, mathematics and physics, "the mother of all natural sciences."

NEW MATERIALS

As the needs of the space age are still only vaguely understood, knowledge of materials that will be required is uncertain and general at best. New properties will be needed, while others now generally thought desirable may become unimportant. For instance, rigidity of an extremely high order will be needed in elements of the navigational apparatus, while oxidation resistance may not be a consideration. Reason: a small error in navigation may result in a final error of millions of miles, and any but the optimum flight pattern would burn too much fuel. And, in oxygen-less space there are no oxidation problems.

Research in the metal and the nonmetal field is being pushed even more to develop knowledge about what controls the properties of materials. These properties are needed in new alloys that might be used in space.

These new materials, as well as some that are already here, may need new techniques to reduce them to the required shape, to achieve dimensional precisions beyond the capabilities of current manufacturing processes.

Sheet metal, whether from existing or from exotic materials, will have to be produced to accuracies of millionths of an inch. Some materials may have to be shaped instantaneously (as by explosion forming) to prevent stress concentrations or work hardening.

POWER SOURCES

Initial lift is expected to be obtained from chemical power sources. Other power sources are being investigated. When the vehicle becomes nearly weightless, small forces applied over a long time probably will be all that is needed to accelerate the vehicle and control its path. Solar energy and ionic propulsion were mentioned.

DESIGN APPROACHES

At present, vehicles for the space program (not missile program) are designed from scratch. Little is carried from one to the next. Each new design requires special electronic and other test equipment. This can't always be produced in time and involves excessive expense.

A new design philosophy now coming to the fore has two main steps: production of "standard" subassemblies to be used as components, and system design to use existing test facilities. These facilities would be equipped with automatic control, and to measure and evaluate data.

Reliability also loomed large at the meeting. Attempts were made to arrive at an acceptable definition of reliability, and how to measure it, but insistence was placed on reliability as a basic design function.

IMPACT ON INDUSTRY

Quality rather than quantity characterizes present work in the field of space flight. This presents new opportunities for small industrial enterprises with high personnel qualifications.

More generally, it was felt that the fruits of research initiated for the space program are sure to trickle down to other branches of industry and become important factors in improving the design of such earthbound products as automobiles, cameras and television sets.

CAA Air Traffic Control Plan Gets First Computer

INDIANAPOLIS, IND.—The Civil Aeronautics Administration has put the first computer in its planned network for modernized air traffic control to work computing and printing flight-progress data, estimating flight-arrival times over checkpoints, and determining airspace conflicts in flight plans.

The pictures of flights passing through this area is shown by progress strips made for each radio fix on a plane passing over or near the area. Data on the plane's flight plan are fed into the IBM 650 RAMAC (Random Access Method of Accounting and Control) and the computer prints flight-progress charts showing the estimated times the plane will pass radio fixes on its particular course. An average of four flight-progress strips is produced for each flight plan.

To find out if two flights are due to arrive over a fix at the same altitude within a 10-minute interval, the Ramac makes a conflict search as the flight-progress strip is being printed for each fix on or near a flight plan. If conflict exists, such a notation is printed on the flight strip. Such conflict detection at computer speeds is important on direct flights, because of the large number of military aircraft which follow direct straight-line routes rather than designated airways.

COMING EVENTS

SEPTEMBER

29-Oct 4 . . . . Society of Automotive Engineers, National Aeronautical Meeting, Aeronautic Production Forum and Aircraft Engineering Display, The Ambassador, Los Angeles.

28-Oct 2 . . . . Pressed Metal Institute, Annual Meeting, The Cloisters, Sea Island, Ga.

29-Oct 3 . . . . American Society of Tool Engineers, Semi-annual Meeting and Western Tool Show, Shrine Exposition Hall, Los Angeles.

OCTOBER

6-8 . . . . National Association of Corrosion Engineers, Northeast Regional Meeting, Boston, Mass.

9-10 . . . . Gray Iron Founders' Society, Inc., 30th Annual Meeting, Sheraton-Park Hotel, Washington, D. C.

9-10 . . . . Society of the Plastics Industry, Inc., 14th New England Section Conference, Wentworth-by-the-Sea, Portsmouth, N.H.

13-15 . . . . American Institute of Electrical Engineers, 10th Annual Machine Tool Conference, Statler Hilton Hotel, Hartford, Conn.

14-16 . . . . American Society of Mechanical Engineers and American Society of Lubrication Engineers, Lubrication Conference, Hotel Statler, Los Angeles.

16-17 . . . . The Magnesium Association, Annual Convention, Fort Shelby Hotel, Detroit, Mich.

18-21 . . . . American Society of Indus-

trial Designers, 14th Annual Design Conference & Meeting, Bedford Springs, Pa.

20-21 . . . . Institute of Radio Engineers, 4th National Aero-Com Symposium, Hotel Utica, Utica, NY.

20-24 . . . . National Association of Corrosion Engineers, Annual Conference and Exhibition, South Central Region, Roosevelt Hotel, New Orleans.

Paris Engineers Study Nucleonics at Night

PARIS—Because of a shortage of nuclear engineers, France is conducting intensive after-hours courses in the industrial applications of nuclear energy for working engineers specializing in other areas.

Engineers taking the 5-month training, must attend 75 90-min lectures. Classroom work is supplemented by lab sessions and visits to nuclear installations. Instruction covers six areas: review of theory, nuclear materials, nuclear electronics, reactor techniques, use of radioisotopes and biological security. Leading French specialists in these fields comprise the "faculty."

Courses are sponsored by the Centre de Preparation Pratique Aux Application Industrielles de L'Energie Nucleaire.

New Day Arriving in US Car Design

DETROIT—George Romney and other American Motor officials are convinced that a new era in automotive design philosophy has dawned. Henceforth, the American car buyer will have a choice of car design that up to now has been limited to the ever-larger, longer and lower models.

They contend that no longer does a car serve solely as the means for family transportation; rather, it is becoming a means for individual transportation—thus more emphasis on function than on exterior styling; more emphasis on reliability than on chrome.

Pointing to their currently profitable selling season when the rest of the auto industry suffers, American Motors officials say their introduction to the US market of the small "economy" car built with a unitized body has taken hold with the "Big Three" and that redesign of cars in the future will be based on mechanical and functional improvements rather than planned obselescence.

READER TO EDITOR

Dixie Honors Yankee Hero

To the Editor:

Your "Interesting to Note" item, "Thaddeus Lowe and His High Balloon" (Sept. 1, p 7) contains an item that presents a peculiar twist of fate. It is interesting that all of Mr. Lowe's work was performed for the Federal troops and the US Government during the Civil War. Here at Fort Rucker, Ala., the Army has its Aviation Center. To satisfy airfield requirements for the extensive training requirements an airfield was recently constructed and dedicated last year. Oddly enough, the name selected for this field is "Lowe Army Airfield," in honor of Thaddeus Lowe.

The point I wish to make is that no public-spirited citizen in the entire South and especially in Alabama, commonly referred to as the "Heart of Dixie," complained about the fact that a portion of the Deep South was dedicated to honor a "Yankee." —CAPT. JOHN C. GEARY
Ft Rucker, Ala

Old Tool Men Never Die

To the Editor:

In glancing through a recent Government bulletin concerning occupations I found no listing for a tool or die designer. In recent months, since the orbit scares from Russia, it seems that everybody has to be a retired military officer or scientist reaching for his PhD to get a job. Of course Walther Reuther, a former toolmaker, has upgraded a nut-and-bolt applier to the realms of a skilled artisan with all benefits at the expense of the consumer.

What happened to the old toolmaker and diemaker who was just coming into his own at the age of 50? Actually, Henry Ford didn't produce anything until he was over 40. I know of a prominent manufacturer of ram jet engines turning down a tool and die man because of his age—too old.

If the Russians do get ahead of us, there won't be a dumping of craftsmen and engineers after they have reached the magic age of 65. —H. E. WATKINS
Chicago

Against Handwriting Analysis

To the Editor:

Now I have heard everything! Employers now are not only supposed to consult sociologists, psychiatrists, personality experts and various authorities in the field of human relations prior to employing personnel, but Mr. George Keinath in his letter to PRODUCT ENGINEERING (Sept 8, p 4) suggests handwriting analysis. Don't you think we are going from the sublime to the ridiculous in even considering such a test prior to employing an individual?

The next step, I assume, will be having an applicant consult an astrologer and then have him go to one of those chaps who feels the bumps on your head. What happened to the old theory that a man is hired and fired according to the work he can produce, not how he dots his "i's," circles his "o's" or because he has had the misfortune of being born under the sign of Aries? I suppose with the advance of technology we must also expect our evaluation of the human machine to follow closely behind. Freud made notable contributions with his studies but let us not retreat to the realm of metaphysics.
—B. DAMELIO
Woodside, NY

Idea Clinic

To the Editor:

Inspiration is an elusive commodity, especially in technical magazines. It is very refreshing therefore to find inspiring articles and editorials in almost very issue of Product Engineering. For this I am grateful.

My quest at this time is for advice and materials toward leading an "Idea Clinic" here in Clearwater under the Adult Education Department of the school system. This "Idea Clinic" is a guided discussion class aimed at the stimulation of creative thought and constructive action. The scope of subjects is unlimited. Inventions, methods, civic improvements, politics, human relations, basic truths, etc will be "hashed-over" under rigid timing control and with leadership seeking to draw out the less aggressive class members while harnessing the promoters and obsessed.

It is also my intention to set up a similar "Idea Clinic" for senior and junior high students who have worthwhile and educational ideas and projects they wish to develop through seminar or individual effort. This clinic would probably be a corporation (outside of the school system) with an office, lab and workshop for experimental and development projects. It would soon become self supporting through sales or royalties of ideas and/or products.

I am sure that you have much material and many suggestions which will be of value in providing stimuli toward this creative project.

Constructive criticism from you, your staff and your readers will be appreciated.
—R. PAUL SNYDER
Clearwater, Fla

● This is an interesting and laudable enterprise that deserves both support and emulation in other communities. We have informed Mr. Snyder of Junior Achievement, Inc, (a means for setting up a junior company to produce a particular product), and the college research method of undertaking some projects aimed at evolving marketable or royalty-producing patents. Any other ideas from readers may be sent to us for compilation and forwarding to Mr. Snyder. If a sufficient number are received, we will combine them into a report.—*EJT*.

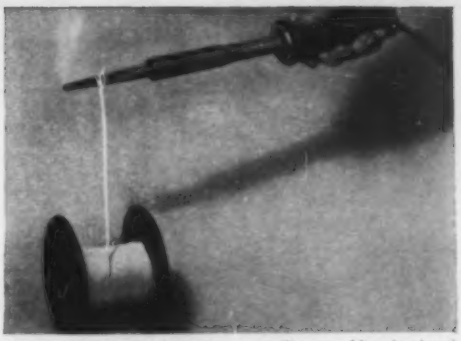
HOW TO SOLVE PRODUCT DESIGN PROBLEMS WITH

GE SILICONE IDEAS

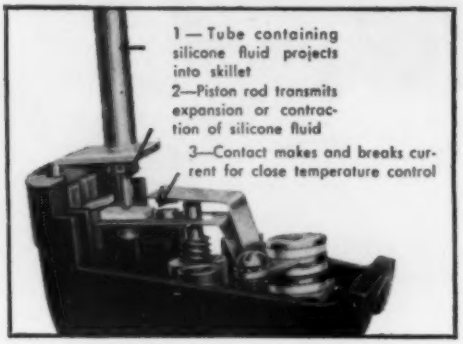
Silicone rubber for wire insulation adds improved physical properties to excellent electrical properties

Always valued for its high performance electrical characteristics at high temperatures, silicone rubber insulation for wire now has improved physical properties. A true elastomer, GE silicone rubber is suitable for thin wall (.012") wire construction, does not tend to cold flow under clamps, can be bent double without cracking, stays flexible down to −150°F.

Even when exposed to a direct flame, G-E silicone rubber still insulates, won't release toxic fumes. Withstands current overloads of 300%-400%, provides a safety margin for intermittent high temperature operation in Class B equipment. Excellent dielectric strength stays high throughout life; service to 500°F—and to 600°F for shorter periods. Features high ozone, moisture and weather resistance, long shelf life.



No damage occurs when you wrap silicone rubber insulated wire around a hot soldering iron, proof of silicone rubber's remarkable heat resistance.


1—Tube containing silicone fluid projects into skillet
2—Piston rod transmits expansion or contraction of silicone fluid
3—Contact makes and breaks current for close temperature control

New appliance thermostat uses silicone fluids for faster, closer temperature control

General Electric silicone fluids, because of their high coefficient of expansion and thermal stability, make possible the extremely accurate temperature control provided by the new G-E appliance thermostat. Reaction time is faster than with bimetallic elements; cost fully competitive.

This is only one example of creative engineering with G-E silicone fluids. Their unique properties—small change in viscosity with temperature, chemical inertness, excellent resistance to shear, oxidation and high-temperature breakdown—make them ideal for such applications as dash pots, vibration dampers, heat transfer fluids, fluid transmissions, etc.

New silicone rubber cures without heat, keeps physical and electrical properties to 600°F

Need to seal or caulk metal glass or plastic parts? Encapsulate or pot delicate assemblies? Mold silicone rubber parts in place? Patch or repair rubber parts? Need a flexible, heat resistant, accurate, self-releasing mold for low-cost plastic tooling or model making?

New G-E RTV (room temperature vulcanizing) silicone rubber will do all this and more. Cures without voids at room temperature in any time you select up to 48 hours. Stable up to 600°F. Tough, elastic, bonds well to primed surfaces. Has good resistance to fluids and fuels. Viscosities from very pourable to spreadable. Solvent free—shrinks less than 0.2% while curing. Write for technical data. Samples available for evaluation—just give us a brief description of your application.

Sample mold of complex part reproduced exactly, including undercuts. RTV cures without voids, without shrinkage.

Write for more information

Operation upturn — General Electric

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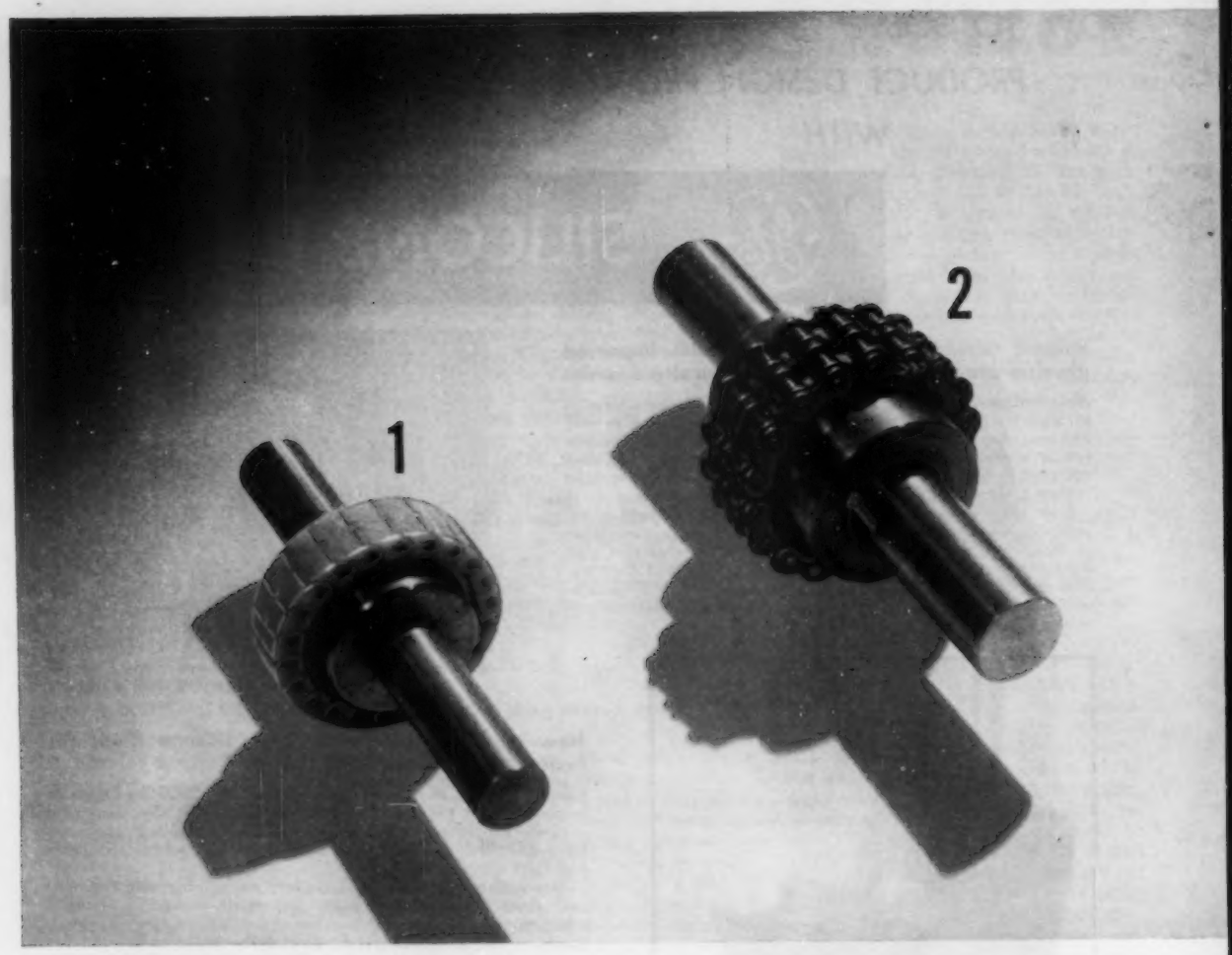


Morse's new Nylon Coupling means:

Nobody can answer your coupling because only Morse offers

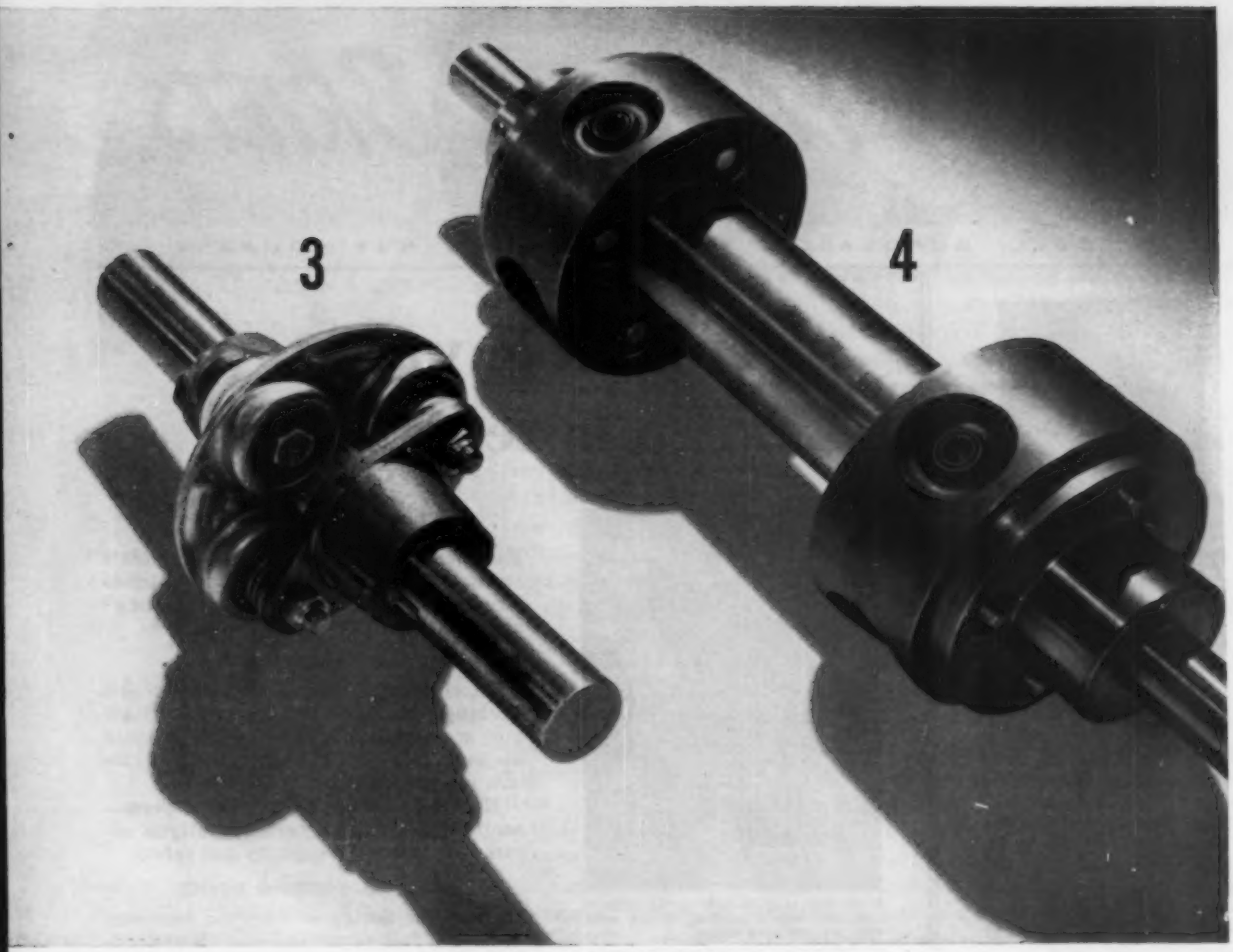
1 New Nylon Couplings:
Cost 20% less than conventional couplings; last indefinitely. Need no lubrication, no cover; take high torque; adjust to misalignment.

2 Flexible Chain Couplings:
For moderate speeds, steady loads. Rugged, economical . . . take higher h.p. per given diameter. Easy to install, align, and disassemble.

3 Morflex Couplings:
Preloaded neoprene biscuit assembly reduces misalignment stresses, increases bearing life; protects machine from shock and vibration.

4 Radial Couplings:
Neoprene biscuits—assembled radially on pins—take heavy thrusts, torques, shocks, frequent load reversals; retain torsional flexibility.

NOTE: All Morse couplings are available in driveshaft constructions.



problems as well as Morse, all four of these flexible couplings

REMEMBER: Nobody gives you a more *impartial* analysis of your power transmission problems than Morse, because *only Morse* offers all four of these basic drives: Roller Chain, Silent Chain, Hy-Vo®, and "Timing"® Belt Drives . . . plus a complete line of power transmission products.

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R B&W FASTENER BRIEFS

RUSSELL, BURDSALL & WARD BOLT AND NUT COMPANY

Technical-ities

By John S. Davey

How to select tapping screws

1. Use *thread forming* screw Type A, B or C when material is ductile enough to stand deforming action of screw. If not, use *thread cutting* type.

2. Type A is used with pierced hole for starting; and where an exposed point doesn't matter. All other cases use B, C, or other blunt screws in drilled holes.

3. When load is no factor, metal gauge determines diameter of screw. Pick a thread pitch which gives at least a full thread engagement.

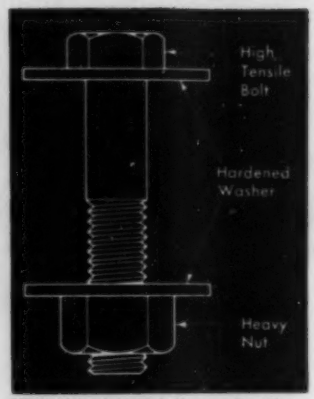
FOR EXAMPLE: Metal .062" thick suggests use of #7 Type A or #10 Type B (both have 16 threads/inch).

$$\text{PITCH} = \frac{1.00}{16} = .0625"$$

4. When you do have loads to sustain, you must consider required holding power. If metal thickness doesn't allow ample thread engagement (so that threads strip), use more smaller diameter screws. They engage more threads. Limiting factors: the screw's torsional strength, and the effort to drive it.

5. If, due to material thickness, screws fail by torsion or drive too hard, select cutting screws (1, F, or 23). For hard ductile materials, the Type 1 is best; for soft, friable materials, the Type 23.

Two basic ways to keep fasteners tight



RB&W high strength bolts permit optimum tightening without crushing surface when used with hardened washer.

Section of Spin-Lock screw. Teeth embed only with proper tightening. Same feature available in nuts.

Fasteners that stay tight keep joints strong. Resistance to loosening depends largely upon: (1) The inherent "locking" ability, (2) The man with the wrench.

HIGH PRELOADING

With rigid type joints, one of the best "locking" fasteners is a standard RB&W high strength bolt or cap screw . . . *torqued up close to its yield strength.* It locks by its own internal residual tension.

High tension not only keeps it permanently tight, but also prevents fatigue, assures optimum load capacity and safety.

INTEGRAL LOCKING DEVICE

Suppose the design of fastened members can't take full advantage of such preloading? Then a lock is needed, such as that furnished by RB&W Spin-Lock® screws and nuts. Ratchet-action teeth bite into seat; require 20% extra torque to loosen.

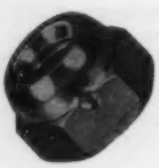
Note that Spin-Lock fasteners seat solidly before locking. The installer can't be deceived. He *has* to tighten properly before feeling resistance.

In both cases above, *positive* tightening assures positive fastening.

Send for Bulletin on Spin-Lock fasteners, or call your local RB&W Fastener Man. Russell, Burdsall & Ward Bolt and Nut Company, Port Chester, New York.

Plants at: Port Chester, N.Y.; Coraopolis, Pa.; Rock Falls, Ill.; Los Angeles, Calif. Additional sales offices at: Ardmore (Phila.), Pa.; Pittsburgh; Detroit; Chicago; Dallas; San Francisco.

Staked acorn nuts lock securely



Staking opposite sides of these RB&W acorn nuts deforms threads for a positive grip. It also puts middle of nut slightly out-of-round, for a spring tension locking effect. They're designed for applications such as outdoor furniture, where anchoring fasteners is more important than solid seating. Available in aluminum, steel, silicon bronze.

These all-metal nuts can also be furnished in regular double chamfered style. Since they lock with their middle threads, they can be turned onto screw from *either* side.

PERSPECTIVES

in design and development . . .

Military Career for Design Engineers

Inasmuch as the US Air Force insists that commanding officers up to the highest echelons be professional pilots, why should its present R & D program be run by nontechnical administrators? This question underlies the campaign among some Air Force personnel to put their complex engineering programs under the guidance of professional engineers.

Col. Edward N. Hall of the USAF Air Research and Development Command feels the Air Force has no policy concerning the engineering profession and that frequently, when official documents list professional activities in the Air Force, engineering is conspicuous by its absence. He believes that engineering should not only be recognized as one of the many professions embraced by the Air Force, but as a key profession among them. He looks at it this way—The R & D programs of the military are the backbone of all the nation's R & D and contribute strongly to the health of our civilian economy."

What Can Be Done?

In his proposals, contained in a paper that has received wide circulation in the Air Force, Col. Hall feels that a typical career pattern for engineer officers should be quickly formulated. This is his plan: The young engineer entering the Air Force in his early 20s would be assigned to test work at some USAF lab—not writing reports about the testing done by contractors or civil service employes—but actual testing. Col. Hall feels "the most important single item in this phase of rejuvenation would be recognition that a major function of these laboratories is to provide adequate training for engineering officers." Fabricating test setups and conducting tests, as well as designing them on the board would give the young engineer experience and confidence in his abilities, unattainable in any other way. Col. Hall adds, "Omission of this sort of work during his 20s almost inevitably condemns a man to second-rate engineering competence for life."

After two or three years in test and design, the young engineer would be designated as a test supervisor who would command, guide and coordinate the work of others in an expanded version of test activity. In his late 20s or early 30s he would then be assigned as a junior project engineer in charge of a limited contractor development program on some specific components like pumps, valves, turbines, amplifiers, gun elements, etc. From here he would graduate to senior project engineer in some lab, in charge of a small project group responsible for the development of major missile or airplane components. From this point these specialists might graduate into high-echelon executive positions in the laboratories, or into weapons systems project office (WSPO) activities. Interspersed through the above career pattern that would span 10 to 15 years would be diversions to various schools and field assignments to acquaint the future WSPO chiefs with Air Force operational activity.

Major military R & D programs are expensive, and important to the industrial economy as well as defense. Such program directors should be of the highest quality in the nation. Concerning expense, Col. Hall states, "To prosecute these extremely important activities in a pattern best described as forging a direct connection between the gold reserves at Fort Knox and the nearest sewer is criminal. Yet, because of the lack of technical judgment in high places, many major military R & D programs fall into this category."

—Paul Anderson

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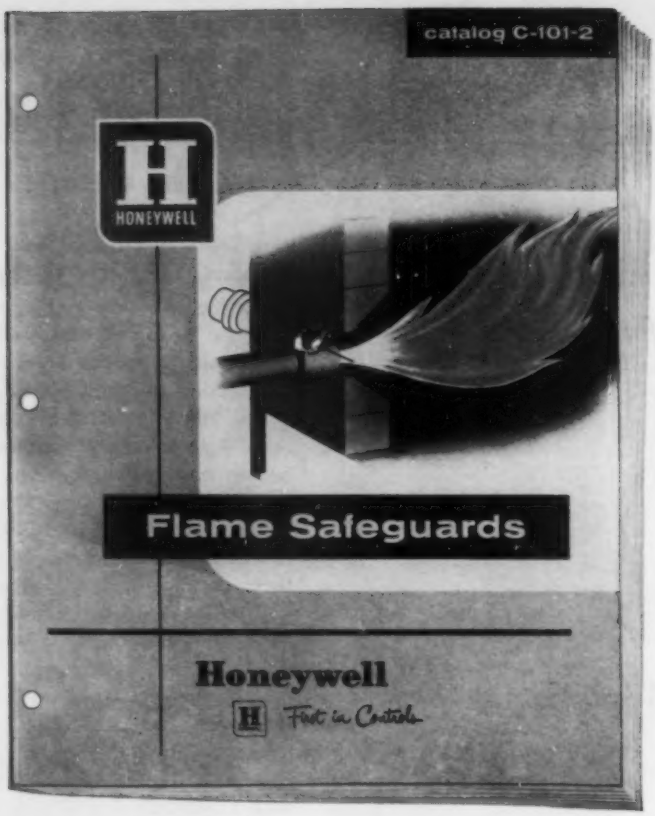

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Product Engineering HORIZONS

September 29, 1958

WHO'S OUT OF STEP?

"Order is heaven's only law." Thus Confucius established that, just as nature is controlled, so man must practice self-control. There has been a tendency to believe that discipline is outmoded, autocratic, that it conflicts with the new freedoms and new customs provided by our greater material prosperity, and our growing awareness of the world outside.

But discipline is essential to operation of any society, no matter how wealthy; we cannot live together successfully without it. It is not inherent or inherited; it must be taught. Presumably, the best time for teaching it is during childhood, yet children today are our greatest problem because every important disciplinary force, starting with the home, seems to be attempting to evade its responsibility. We have no modern equivalent of Chinese ancestor worship, Near East family and tribal living, the Basque matriarchy or the German patriarchy.

We have too little of the consistency and fairness that characterized those disciplines also. To the Roman, the soldier who attacked contrary to orders was more deserving of punishment than the one who turned tail; to the Greek, it was consistent to give a general a garland for winning a battle—and to fine him 1000 drachmas for going out to battle personally unarmed.

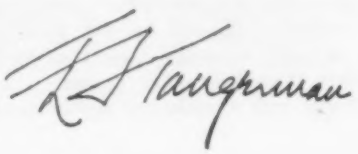
Nowhere is the problem of discipline more apparent than in business, where a great variety of people is assembled in a complicated social setting. Nowhere else are habits, customs, conventions and laws so blended together to determine day-to-day procedure.

Many of these taboos and restraints are outmoded, but some must be maintained if business is to operate. And it is management's responsibility. The group must work together, regardless of petty personal likes or dislikes. Each member must be considerate of the feelings and rights of his fellows, must carry his fair share of the work load, must temper his devotion to his own interests with regard for the interests of others—and management must, in the ultimate, see that he does.

The trend away from autocratic management, from rule by force to management by reason, poses a host of new problems.

Knowledge, tact and integrity must replace bull voice, hard fist and the threat of firing. The manager today must win respect and affection, he must maintain discipline by suggestion and example. And each individual must be self-disciplined or the suggestion and example fall on dead ears.

It is fine to be an individualist, and very rewarding. But the individualist must be certain that he doesn't gain and maintain his position at the expense of everyone else. Only by exercise of personal discipline can he be what he wants to be and still get along with others. Without it, he becomes the misfit, the bohemian, the odd ball, the man who knows everybody else is out of step.



Forging or extruding, they can deliver a squeeze measured in thousands of tons. But the Air Force-subsidized heavy presses aren't keeping busy, causing some critics to call them vastly over-designed "white elephants." In reply, the author judges them by a novel way of cost-estimating heavy parts and cites five new process areas that show how . . .

THOSE HEAVY PRESSES

R W SMITH,
Cost Analyst, The RAND Corporation

Has the US Air Force heavy-press program resulted in heavyweight tools of doubtful value? Since World War II the government has underwritten construction of 11 giant forging and extrusion presses. Their tremendous capacity, as such, is a national asset when it comes to building aircraft. But some critics point to lack of sufficient work to keep all these heavyweights busy, and consider such capacity wasteful. This is a narrow view. Design stands to gain much from these presses ranging from 8,000- to 50,000-ton capacity. They offer two kinds of help:

Design of the future. Calling them forging and extrusion presses seems to have blocked off thinking of their usefulness for other industrial purposes. Besides the work load originally planned for them, there are potential new or unusual uses—resulting, for example, from advances in powder metallurgy, cold-forming, and fusing. These could easily crowd the presses to capacity.

Design right now. The presses should be judged, not so much on the hours they run, as on usefulness of the work they do. The advantage of forgings and extrusions is that they result in pieces of equipment that are better or cheaper, or both. These benefits, in turn, can lead to increased efficiency and lower cost for an entire assembly.

Future Work Load

Investigation should be started to uncover new applications in both the metal and nonmetal fields for the "big squeeze" principle. The presses certainly have a greater potential than current usage suggests.

• Among potential uses for the forging presses, perhaps the most exciting stems from results of experiments with powdered metals. Forged sheets of some metals made this way have considerably improved characteristics of the metal. If further work confirms the preliminary results, demands on the forging presses could exceed present capacity.

• A unique method of synthesis that uses high-pressure metallurgy promises increased strength from accepted alloys. For example, extrusions made from small magnesium pellets formed at high pressure have given structural shapes with considerably higher compressive yield strength than from standard magnesium extrusions (*PE*—May 12, '58). The process requires no sintering.

• A new fusing process has been developed that produces a more uniform quartz with less thermal strain. This material, adaptable to forging, retains its characteristic optical and dielectrical properties. Its possible application for missile cones suggests putting the big forging presses to work.

• The last few years have shown marked improvement in the forging of titanium. Now, a technique for extruding titanium, announced by Battelle Memorial Institute, not only reduces chip removal but gives a surface finish comparable with smooth machine turning and a tensile strength increased as much as 30%. This development should make greater demands on the big presses.

• New cold-forming techniques have resulted in markedly improved properties of finished parts—tensile, fatigue, and yield strengths, and surface finish. At Ford Motor Co, for example, a machined piston wrist pin that withstood less than 20,000 cycles in a fatigue test was able to take more than 50,000 cycles when cold-extruded.

What the Presses Can Do Now

Decision on the fabrication method for heavy components involves three principal criteria concerning cost. Here is where what the heavy presses can offer is worth a second look:

Fabrication cost itself—the estimated savings possible in production cost, when compared with the best alternate fabrication method. How to calculate this cost component is well understood by industry.

Product cost—estimated savings from other changes in the product that result from using forgings or extrusions. This can often be more important than fabrication economy but all too often is not taken into account. True, this estimate can be complex, difficult and uncertain—but it can be simplified considerably.

Let us take airframes as an example. Here, forgings and extrusions are likely to result in weight-saving. This can result in improved airplane performance or in still

HEAVY PRESSES—WHERE THEY'RE LOCATED

Operator	Location		Type of Press
Alcoa	Lafayette, Ind.	Extrusion	14,000-ton Schloemann
Kaiser Aluminum	Halethorpe, Md.		8,000-ton Loewy (2)
Harvey Aluminum	Torrance, Calif.		8,000-ton Loewy
			12,000-ton Lombard
Curtiss-Wright	Buffalo, N. Y.		12,000-ton Loewy
Dow	Madison, Ill.		14,000-ton Hidraulic
Alcoa	Cleveland, Ohio	Forging	35,000-ton United
			50,000-ton Mesta
Wyman-Gordon	N. Grafton, Mass.		35,000-ton Loewy
			50,000-ton Loewy

CAN PAY OFF

Wyman-Gordon's 50,000-ton forging press.

further reduction in weight. Normally it is the former that occurs even though it may not be recognized as such. In the constant fight to hold down weight, what is saved on our hypothetical forging is likely to become just another item in the total. Yet performance will benefit from the lighter airframes, and methods exist for evaluating it. But they involve complex judgments of aircraft capability, usually in some assumed operational environment.

On the other hand, if performance is held constant, further savings attributable to reduced weight are easily calculated. This additional saving depends on that part of the weight-range curve to which the airplane is designed. Tactical aircraft, for example, are high on this curve: a pound added to a part may require 10 more pounds of structure to maintain the same range. This factor may be determined for each type of airplane. The product-cost saving can then be calculated from this factor, the cumulative average cost per pound of the airframe and engine, and the number of airplanes produced. The method is not only quick, easy, and meaningful, but can be standardized.

Such savings can become big money. Assume a supersonic airplane whose airframe has a cumulative average cost, at quantity Q, of $100 per lb. If using a forging results in saving 10 lb, potential reduction of airframe weight might be 100 lb. The potential saving in airframe cost is, therefore, $10,000. Also, because of the lighter airframe, engine requirements will be reduced too. This could increase total product-cost saving to, say, $12,000 per airplane—or a potential saving of $1200 per lb of eliminated weight.

Airplanes are only one example. The same approach applies to any product in which forgings or extrusions result in weight reduction. And at the very least, a pound of component is a pound of product and in this case, the factor is one, not zero.

System cost-savings are possible too, but more elusive. When a product changes, all associated initial and annual operating costs are also subject to change. A product of equal performance capability but lighter in weight than an alternate might result in not only reduced cost of material but also in decreased shipping and handling charges, reduction in installation and floor-space requirements, and possibly even in fewer spares needed in stock. These reductions in turn lead to lower annual operating expenditures. The initial investment, for any piece of equipment, plus operating costs for the estimated life, less any salvage value, comprise the total cost. This is how costs of two or more items can be compared, and usually are. Note that the difference should be credited to the process that made the lighter product possible.

For example, significant variations in structural weight of modern military aircraft were found to change maintenance and other related costs by impressive amounts: A 1000-lb variation was assumed in certain bombers, and the effect on initial investment cost and five years of annual operating expense was determined. In all cases the "system-cost saving" exceeded the "product-cost saving"—in some instances threefold. Here is why:

A change in size and weight of the aircraft affects requirements for fuel, hangers, and handling and special equipment, as well as airframe and engine spares. Major increases or decreases of maintenance personnel have a multiplying effect on support-personnel requirements. Expenses such as training, salaries and travel vary directly with manning, and there are other related costs.

Variations in system cost are not confined to aircraft, although probably of greater importance here than for most other types of equipment. Nonetheless, this measure of saving should be considered for any systems that are sensitive to equipment change, and the resulting savings credited to the process that brought them about.

EDITOR'S NOTE: For more information on the US Air Force heavy-press program, its origins, accomplishments, and special design features of its equipment, see "A Review of the Heavy Press Program," Oct '56, p 135.

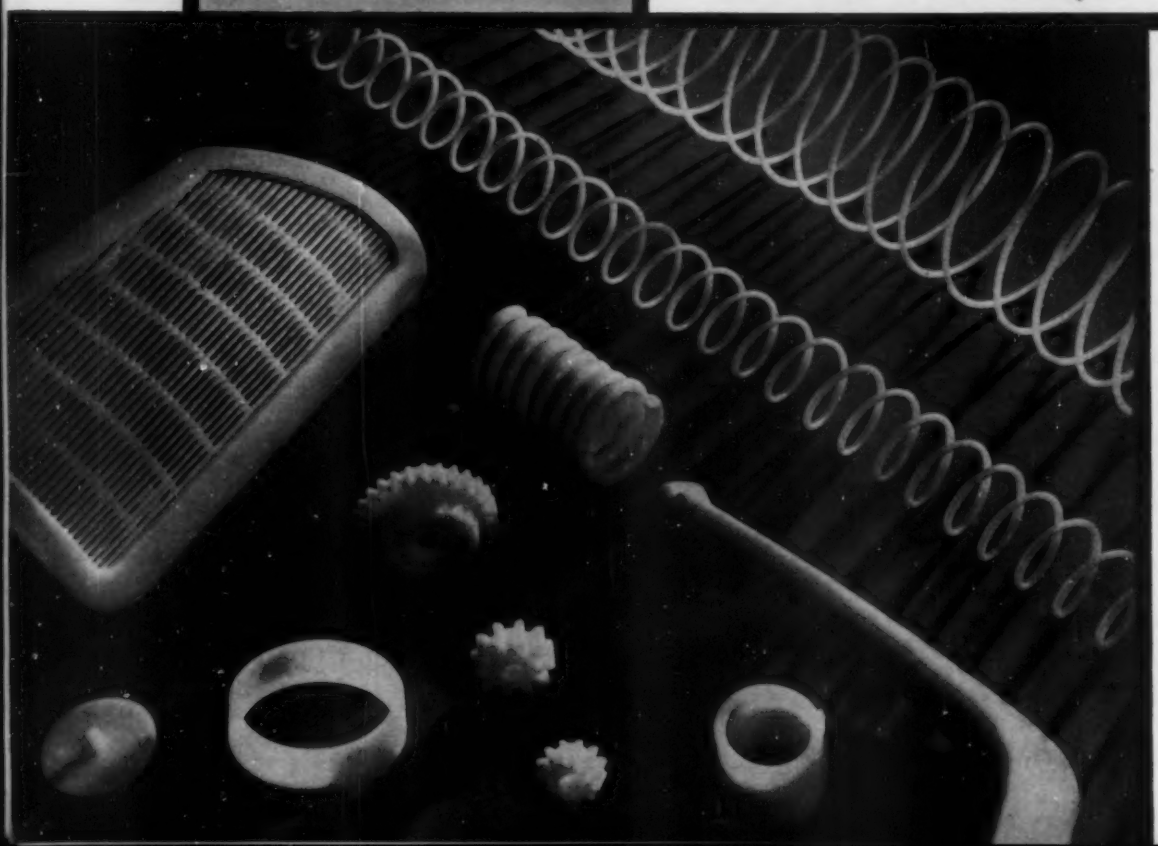
A PRODUCT ENGINEERING STAFF REPORT:

THREE NEW TOUGH, RIGID THERMOPLASTICS: a comparison

FORD R PARK, Associate Editor

1958 has been a good year for designers of plastic parts: three important thermoplastic resins have been introduced that have excellent structural properties over a wide temperature range. Here is an up-to-the-minute evaluation of all three, containing much unpublished data.

DELRIN ACETAL RESIN . . .
displays its best qualities in these experimental parts: high elastic modulus and low creep rate are needed in springs, including the split-ring design in foreground; low friction coefficient, good resistance to creep and impact loads, low moisture absorption are all musts for plastic gears and bushings; good impact strength and stiffness fit needs of the auto radio grille, and the V-shaped refrigerator handle at lower right.



Thermoplastic resins are rapidly approaching thermosetting resins and even some metals in strength level and ability to take abuse over a wide temperature range. The chief problem facing design is the bewildering rapidity with which these new materials have been emerging from the laboratory.

Three of them causing considerable stir among design engineers in the past year are DuPont's Delrin acetal resin, General Electric's Lexan polycarbonate resin, and two polypropylenes – Hercules Powder's Pro-fax and Montecatini's Moplen. Why the excitement? These materials extend the range of tough, rigid thermoplastics; they stem from three different areas of high-polymer technology; they are a giant step toward a whole new family of resins with metal-like properties.

How competitive are they? Every producer of a new thermoplastic argues – with considerable justification – that its brainchild knows no competitors. Much sales effort goes to playing up the unique features, whether price, strength, impact toughness, corrosion resistance and so on. The final choice, of course, lies with the designer – after carefully comparing the strengths and weaknesses of candidates for the job he wants done. In this sense the new thermoplastics are indeed competitors, and the designer cannot overlook any of them.

To assist in PRODUCT ENGINEERING's evaluation, the most recent data on all three resins were examined and pulled together wherever valid comparison of properties was possible. Fortunately, this covered most of the areas of interest in design. DuPont's nylon, Zytel 101, is included, where possible, as a point of reference since it is so familiar. A word of caution: most applications require a combination of properties, and the material selected cannot be weak in any critical area. Thus, laboratory results as reported here are a good guide, but the final choice should rest on tests of the part in the time-temperature-environment conditions expected.

THREE NEW PLASTICS – Where They Come From

DELRIN ACETAL RESIN . . .

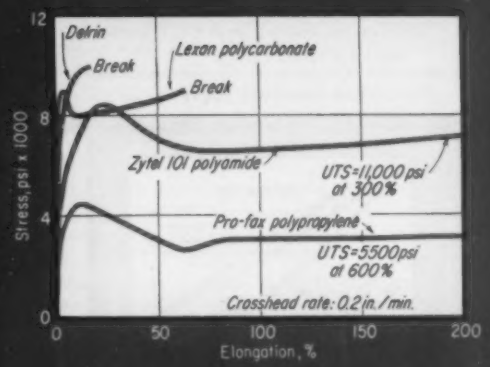
is a product of extensive DuPont research on ordinary formaldehyde. This reactive chemical was tried as a basic thermoplastic building block for many years. The short length of its polymer chain, its poor mechanical properties and thermal instability were major obstacles – now overcome in Delrin. DuPont has elected to conduct an elaborate end-use evaluation program backed up by exhaustive laboratory tests before marketing its product. Thus, although Delrin is not yet available, much design data has been collected. And DuPont plans commercial availability in mid-1959 from a full-scale plant in construction at Parkersburg, W. Va. Announced introductory price: $0.95 per lb.

LEXAN POLYCARBONATE RESIN . . .

is GE's new member in a family of plastics based on phenols reacted with ketones. Its basic building block – bis-phenol A – is in epoxies too. Lexan was chosen for extensive development because of its high heat-distortion temperature and outstanding impact resistance. Priced high – the process is inherently rather expensive and present production facilities small-scale – Lexan hopes to capitalize on those two features. It is available commercially in modest quantities from a new semi-works plant at Pittsfield, Mass. Current price: $2.50 per lb.

PRO-FAX POLYPROPYLENE RESIN . . .

is by Hercules Powder Co and one of several polypropylenes, newcomers to the polyolefin family – whose most famous member is polyethylene. Highly crystalline, polypropylene derives from common propylene – catalytically converted to a high-molecular-weight plastic. Much of the basic understanding of polypropylene's crystalline structure has been supplied by Montecatini, the Italian chemical giant, which has set up the Chemore Corp here to market its own product trade-named Moplen. Hercules emphasizes additives for thermal stabilization – important in fabricating large molded parts – and is producing Pro-fax at its Parlin, N.J. plant: capacity, 20 million lb per year. A third firm, Enjay Div of Esso has announced plans to produce polypropylene in 1960; and Eastman Kodak is now in pilot production. Current price: $0.49 per lb.



Stress-strain curves . . .

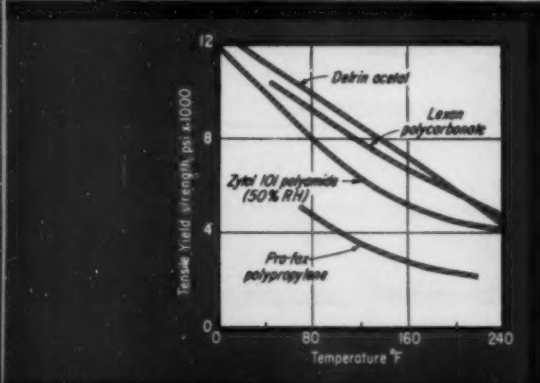
compare the three new plastics with the most common nylon grade, Zytel 101. Note that both Lexan and Pro-fax behave much like ferrous alloys. Delrin has a less well defined yield point – more like nonferrous alloys. Such analogy can be pushed too far, but the two plastics categories in vogue a decade ago – "amorphous" and "crystalline" – seem hair-splitting when used for resins with these strength levels.

Transparent resins are generally amorphous: the cloudy or opaque ones are to varying degrees. All three new resins are crystalline; some are just more crystalline than others. Lexan, though it is termed amorphous, and is transparent in molded form, is about 10-20% crystalline. Delrin, called a crystalline material is 75% crystalline and is translucent-to-opaque in molded parts, depending on thickness. Polypropylenes are highly crystalline and Moplen, Montecatini's product, is sold in several grades differing principally in crystallinity. Note also the high percent-elongation of Pro-fax compared with Delrin and Lexan. Where safety factors are close to unity and full strength is desired, deflection limitation in the part may point to one of the two less ductile resins.

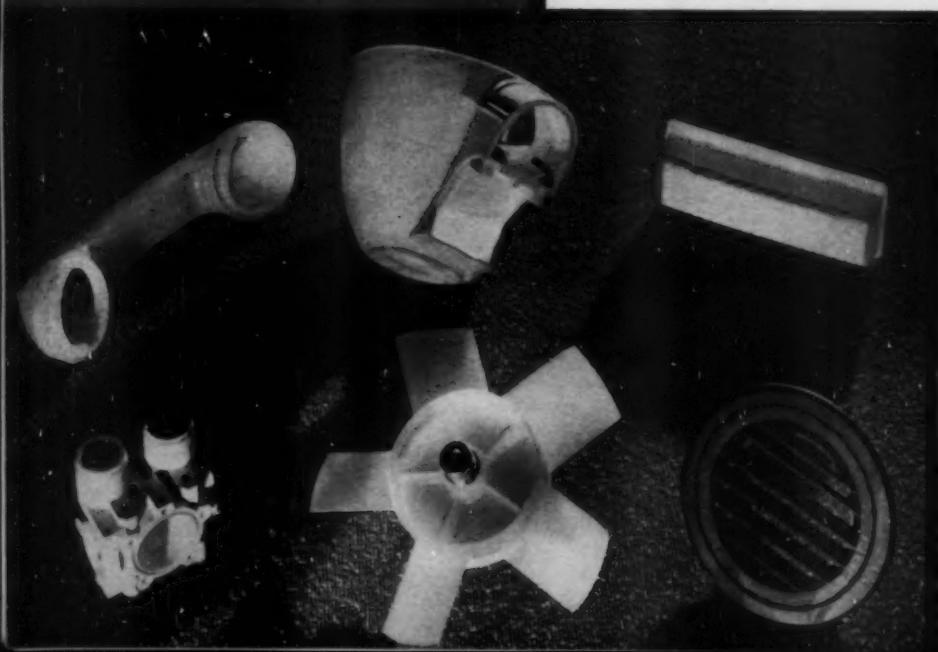
COMPARISON OF PLASTICS PROPERTIES (at average air exposure, 73 F)

	PROPERTY	Lexan (polycarbonate)	Delrin (acetal)	Pro-fax (polypropylene)	Zytel 101 (polyamide)
Mechanical	Tensile strength, psi x 10^3	9-10.5	10	4.3-5.7	11
	Tensile modulus, psi x 10^3	320	410	170	220
	Elongation, %	60	15	220	300
	Flexural strength, psi x 10^3	11-13	14	7.7	14.6
	Izod impact strength (notched), ft-lb/in.	12-16	1.4	1.0	2.0
	Rockwell hardness, R-scale	118	120	95	108
Thermal	Heat-distortion temp. (264 psi), °F	285	212	140	150
	Heat resistance (continuous) °F	275	185	250	250
	(intermittent), °F	285	250	300	300
	Expansion coeff., in./in./°F x 10^{-5}	3.9	4.5	4.7	5.5
	Conductivity, btu/hr/sq ft/°F per in.	1.33	1.60	0.95	1.68
	Flammability, in./minute	self exting.	1.1	0.7	self exting.
Electrical	Dielectric strength (ST), v/mil	400	500	800	385
	Dielectric constant	3.2	3.7	2.3	3.9
	Volume resistivity, ohm-cm x 10^{14}	210	6	20	.5
General	Specific gravity	1.2	1.43	0.90	1.14
	Specific volume, cu. in./lb	23	19.4	31	24
	Cost, cents/cu in.	10.8	4.9*	1.6	4.9
	Clarity	transparent	translucent	translucent	translucent
	Mold shrinkage, mil/in.	5-7	20	10-25	15
	Moisture absorption (24 hr), %	0.2	0.12	0.03	1.5
	Abrasion resistance (Tabor CS17 wheel), mg/1000 cycles	24	20	18-28	6-8

*Announced introductory price

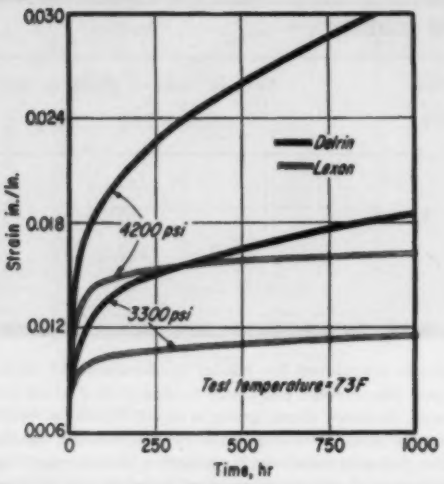


Tensile strength . . .
is determined from short-time loading. As such, tensile strength has limited usefulness in design of thermoplastic structures, except where high dimensional recovery is desired, because these materials show creep. Nevertheless, high tensile strength is desirable—allowing load levels to approach those of metal parts. How tensile strength drops with rising temperature often determines whether a plastic-for-metal substitution can be made. At elevated temperatures, Delrin and Lexan have the edge—they start with high room-temperature tensile strength, and retain about 50% of it up to 212 F. With the usual safety factor of 4, this still leaves a respectable strength for design. Pro-fax, though it shows less drop-off with temperature, starts with a much lower room-temperature strength and thus suffers in comparison. But here the lower cost of polypropylenes allows parts with thicker section for equivalent strength at a competitive price.



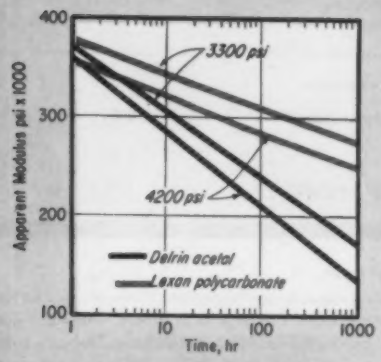
PRO-FAX POLY-PROPYLENE RESIN. . .
shapes under field evaluation, top row from left: telephone handset gets stain resistance along with impact toughness; midget vacuum-cleaner shell is lightweight and resistant to accidental dropping; auto dome light shield is translucent and heat-resistant. Lower row: washing machine mixer-valve fights off detergent action and retains dimensions in water; air-conditioner fan resists creep deformation and runs quietly; auto-heater duct grille takes continuous heating—low cost favored polypropylene.

THREE NEW THERMOPLASTICS



Creep . . .
occurs when a plastic continues to deform with time after a constant continuous load is applied. This cold flow is similar to metal behavior at high temperature, but with plastics it can cause trouble at room temperature or below. How stress will deform a plastic in a set time is important where clearances are critical (in gears, cams, blower wheels, for example), and where constant load must be maintained (as in fasteners, pressfits, and spring members). For each temperature level, a plastic has a family of creep curves for various stress levels, requiring considerable data for a clear picture of its creep behavior. Also, creep tests are usually run under simple tensile-stress conditions, and extrapolating to the more practical cases of biaxial and triaxial stress is often hazardous.

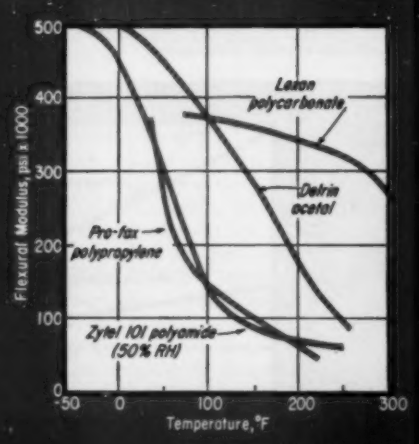
Compared above are Delrin and Lexan at room temperature for two fairly high stress levels. Here, Lexan is more creep-resistant than Delrin, though the total deformation at 1000 hr for the latter is not unusually high—about the same for Zytel 101 nylon, generally considered a creep-resistant thermoplastic. Lexan also reaches final deformation more rapidly; a part in service thus attains its final dimensions quicker; and short-time tests can predict long-time creep behavior more accurately. Creep data for Pro-fax is not yet available, but its short-time tensile behavior indicates a probably lower creep resistance than Delrin or Lexan.



Apparent modulus . . .
makes creep data useful in standard design equations: it allows calculating the deformation to be expected under prolonged loading, or the size of a part for a given ultimate deflection. By definition, the apparent modulus is the stress level divided by the total deformation which would occur in a creep test up to the time in question—the material, in effect, has a family of elastic stress-strain curves, each with a lower slope (and hence elastic modulus) as time progresses. The designer then uses in his equations whichever "apparent" modulus conforms to the time period involved.

The creep data in preceding set of curves can be transposed to the apparent-modulus curves above by successively dividing the stress level for a given creep curve by a series of creep strains corresponding to various time intervals. Plotting the resulting quotients against the same times gives the apparent-modulus curve for that stress level. Designing a member from such a curve is a cut-and-try procedure.

Since Lexan creeps slightly less than Delrin, apparent modulus for Lexan is higher for all time intervals—hence less beam section is required for the same creep loading. For simplest design, curves at a series of stress levels are desirable, though limited interpolation here is possible. Data on Pro-fax polypropylene is not yet available.



Stiffness . . .
is measured by flexure modulus, the value of E determined from a simple beam-deflection test. More precisely, stiffness is the product EI, with the plane moment of inertia I reflecting the distribution of material in the section. Together with impact strength, stiffness sets min thickness, hence volume of material needed. Volume, in turn, determines cost. Delrin is distinguished by exceptionally high modulus at room temperature, but as temperature rises, the advantage is lost to Lexan, with its exceptional heat resistance. Even at 250 F, though, Delrin exceeds 100,000 psi in modulus, a commonly accepted low limit for "rigid" thermoplastics. Although Pro-fax stays above this boundary only up to 150 F, the designer can redistribute the same amount of material in a deep section with larger I, or take advantage of polypropylene's lower cost to beef up thicknesses all around. This can cause trouble, though, if already existing dies are being used—or if the part must mate with existing components.

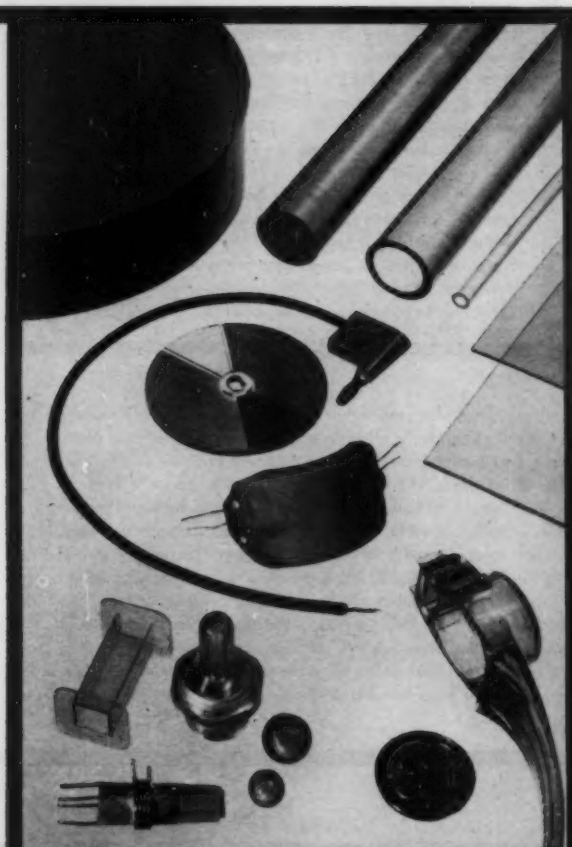
IMPACT STRENGTHS AT 50% RELATIVE HUMIDITY

Material	Notched Izod Impact, (ft-lb/in.)			Tensile Impact, (ft-lb/cu in.)
	—40 F	73 F	122 F	73 F
Lexan polycarbonate	1.6	12-16	—	750
Zytel 101 polyamide	0.5	2	2.3	410
Delrin acetal	1.2	1.4	1.4	233
Pro-fax polypropylene	0.6	1.0	—	185

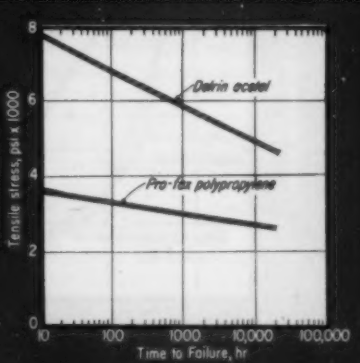
Impact toughness . . .
is a controversial property determination. Some plastics have more capacity to absorb impact energy than others. The main question is: What should be the standard of comparison? The only valid one is to test finished parts, each made from a different resin, in actual service — or under conditions closely resembling same. The more common tests — Izod, Charpy, falling weight, etc. — have proved rough guides and no more. They are well suited to quality control, less suited for design, because: there exists no full understanding of the impact behavior of visco-elastic materials, so we have no test yet that fully reflects this behavior; and for the tests that do exist, including the newer ones, additional studies are needed to standardize machines and specimens and to isolate the effects of velocity, repeated impact, specimen size, notching, etc.

Experience shows, however, that plastics with notched Izod impact values of about 1 ft-lb/in. or higher are tough enough to be seriously considered for impact applications. All three new resins meet this criterion, and Lexan exceeds it by a whole order of magnitude, as shown above, going to about 15 ft-lb/in. Lexan also does not shatter as its limiting impact value is reached, but deforms much like a ductile metal. Such elongation during impact loading is a key feature of true impact-resistant materials, and all three new plastics behave this way to a marked degree. But a material that uses gross deformation before break to gain a high Izod impact value, may deform so much in actual impact service that the part becomes useless.

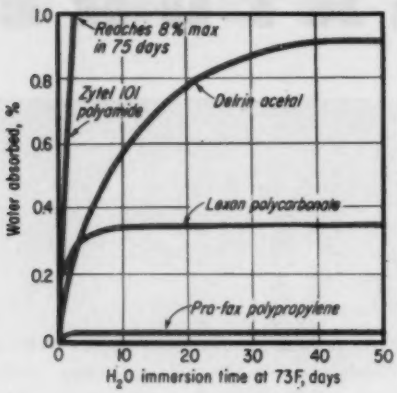
One strong feature of Delrin, as shown by this data, is that it retains a constant energy-absorption capacity over wide temperatures. The same holds for Pro-fax, though only data for the low-temperature range is available so far. The tensile impact test, data from which is included above, has received considerable attention recently as a modification of the Izod test.



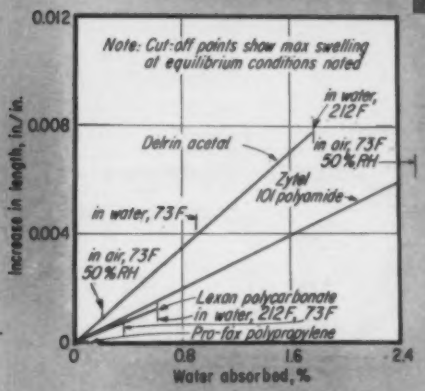
LEXAN POLYCARBONATE RESIN . . .
has some other outstanding properties besides high tensile strength: very high impact toughness, high heat-distortion point, and good creep resistance. These and other properties are features of the production parts grouped here below row of common shapes available. Three in center group: elbow-type electrical connector, temperature-indicating disk, aircraft instrument light-diffuser. Lower right: microphone housing, snap-fit cover for camera lens. Lower left: coil form, high-pressure hydraulic sight-glass, bearing balls, magnet coil cemented with Lexan resin adhesive. Lexan resin finishes can be applied by fluidization or by solution-coating techniques.



THREE NEW THERMOPLASTICS



Moisture absorption . . .
is a design headache for many structural plastics because it is usually accompanied by swelling. Critical dimensions of a part thus may change during operation. Above, the three new resins are compared with Zytel 101, a difficult resin in this regard — though sufficient data and experience now exist to predict its moisture behavior accurately. The curves show Pro-fax is clearly the least affected by water at room temperature. This is also true at higher temperature: in boiling water, percent absorbed roughly doubles for both the Lexan and Delrin resins, while response of Pro-fax remains the same. These curves also point up the danger of relying too heavily on ASTM specifications data — the 24-hr moisture absorption commonly used for comparison is but one point early on the curve, so does not represent equilibrium conditions for the three resins.



Moisture-swelling . . .
data is more useful than moisture-absorption data because it shows the practical effects of immersion. However, the curves above are themselves taken from test specimens, and cannot always predict changes in distance between two points on a plastic structure. Also, plotting length change against percent moisture absorbed can be deceptive: here, Delrin looks worse than Zytel 101—until equilibrium absorption conditions are spotted in. Thus, at 73 F and 50% RH, Zytel 101 swells about 0.006 in./in. whereas Delrin swells but 0.001 in./in. Of the three new resins, Pro-fax is most suitable for water exposure conditions, showing zero swelling—even in boiling water. Lexan also shows exceptionally low swelling. The low sensitivity of the three new structural plastics to moisture, plus their high heat-distortion temperatures, make the domestic appliance market a natural target — for example, dish and clothes washers, dryers, and kitchen ranges.

FATIGUE ENDURANCE LIMITS (10⁴ cycles), psi

Material	73 F—50% RH	73 F—100% RH	150 F—100% RH
Delrin acetal	5000	5000	3000
Zytel 101 polyamide	3000	1500	2000
Lexan polycarbonate	2000	2000	—

Fatigue endurance limits . . .
for tough, rigid thermoplastics can be determined the same way they are for metals. All materials, under repeated cyclic stress, fail at stress level below the static strength. Designing below endurance limit insures satisfactory performance even though the part may be stressed millions of times—a gear, for example. Generally, stress rates up to 1800 cycles per minute will not adversely affect the endurance limit of the three plastics. Higher frequencies may generate enough internal heat to lower fatigue resistance. The comparison above shows humidity influences on endurance limit are nil, but elevated temperature has a lowering effect. Zytel 101 polyamide, however, is more susceptible to fatigue as humidity rises. Data for Profax polypropylene resin is not yet available.

Stress-rupture strength . . .
measures stress causing rupture in a specified time; is used where fracture, rather than deformation, is the criterion of failure — in pressure vessels, pipe, valves, latch parts and the like. Data, left, is based on simple tensile loading. For multi-axial stress conditions, it should be applied with care — may even require testing that closely simulates the actual stress system. Simplest way is to use hollow tubing under various combinations of axial load, bending, or torsion—with or without internal pressure as needed. In design, standard safety factors should be applied to stress-rupture data. Delrin is much more resistant than Pro-fax to stress-rupture failure—but for its strength level, Pro-fax holds up very well with time. At higher temperatures, values for both resins would be proportionately smaller. Stress-rupture data is still lacking on Lexan.

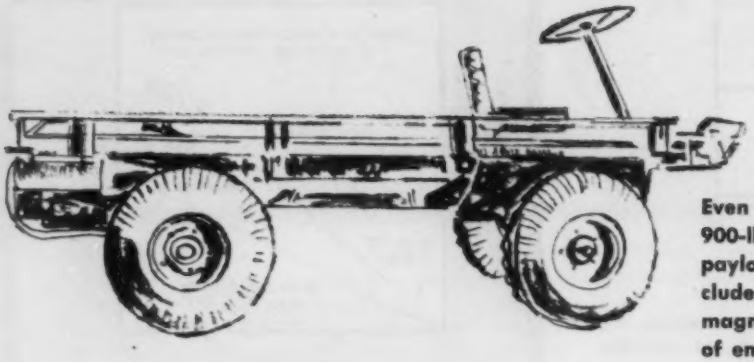
REPRINT of this article can be obtained for your reference file by checking No. E43 on one of the Reader Service cards inside back cover. For other reprints available see page 75.

EDITOR'S NOTE AND ACKNOWLEDGEMENT: This article is based on extensive discussion with technical personnel of: E. I. DuPont de Nemours and Co, General Electric Co, Hercules Powder Co. For other aspects of thermoplastic part design, see:

"Plastic Extrusions," Nov. 25 '57, p 84, tells how to simplify part design through extrusion plus secondary fabrication.

"How to Design Cost Out of Plastic Parts," Oct. 14 '57, p 77, charts classify materials and processes.

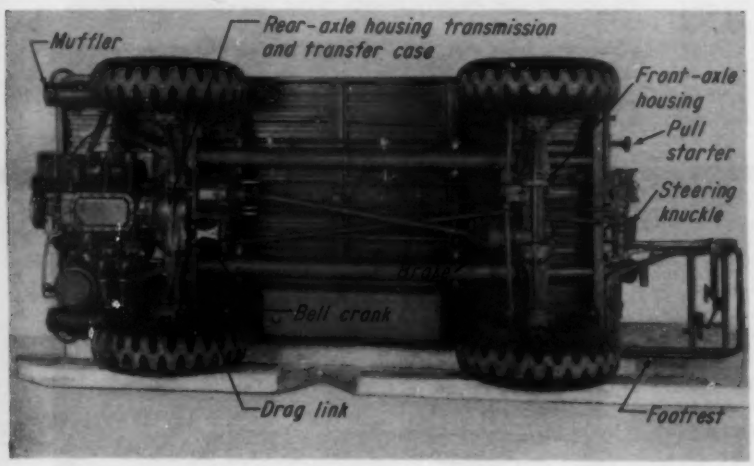
"How to Choose Tough, Rigid Thermoplastics," No. '56, p 167, compares 28 compositions.



Even a Jeep would loom beside Willys' new, 900-lb vehicle. Yet it can carry 1000-lb payload. Extensive use of light metals includes aluminum engine and extruded magnesium platform. Air cooling cuts weight of engine and balloon tires eliminate all springing.

Full name for this "Mechanical Mule" is "M-274, 4 x 4, ½ ton, Weapons Carrier." A driver's seat is provided but a jointed steering wheel permits the operator to walk or even crawl behind the moving vehicle. Produced by Willys Motors, Inc, Toledo.

this MECHANICAL MULE is lightweight— but MUSCULAR

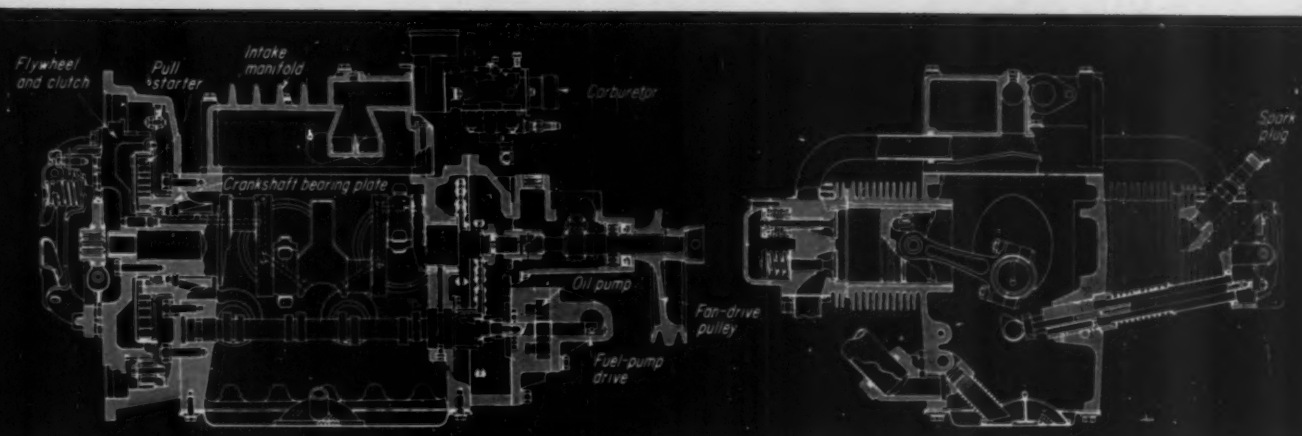


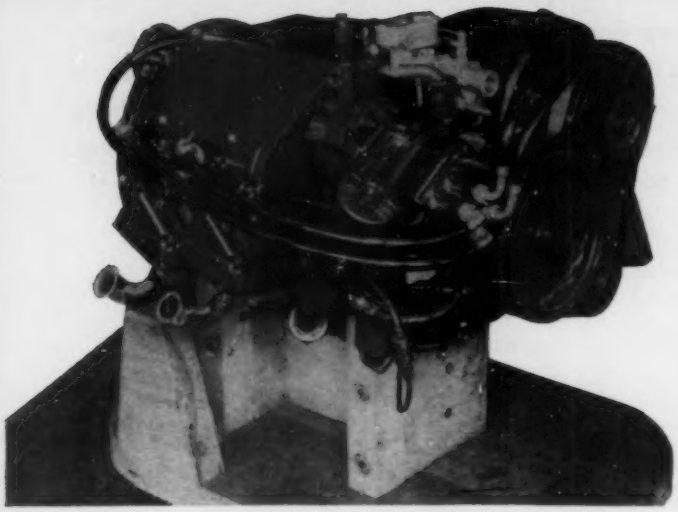
Underside of mule . . . reveals numerous unusual construction features. Principal longitudinal members are pair of large-dia (3.50 in.) thinwall (0.083 in.) welded steel tubes. Flanges at their ends are bolted to aluminum axle housings—the main crossmembers. Low-pressure tires (12 lb) are large (7.50 x 10). Mounted on magnesium rims, they cushion the rigidly mounted axle housings—no springs or shock absorbers needed. Rear-axle housing, transmission, transfer case and engine bolt together for one rigid assembly. Dual mufflers, mounted on the body, are connected to engine by flexible metal tubing. Full-floating drop gear axles are driven by spiral level gears without differentials.

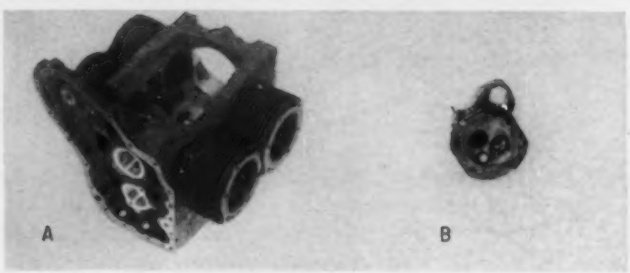
High road clearance (12 in.) is achieved by the final-reduction drop gearing at each wheel. Two-piece drag links and bell crank on each axle are operated by a cam-and-lever steering knuckle mounted on forward edge of chassis. Universal joints at each wheel permit all-wheel steering. Braking for driving and parking is with a single, mechanically operated unit mounted on propeller shaft.

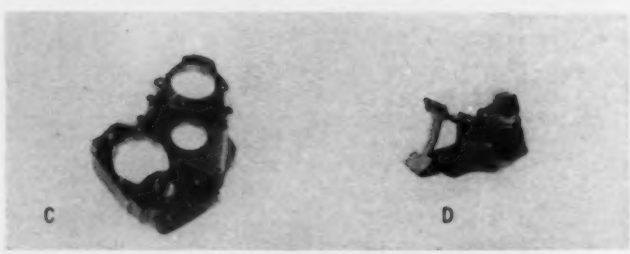
Quick-disconnect fitting on clutch, brake and accelerator permit rapid removal of the tubular footrest—operator can now walk while driving. Manual starting, magneto ignition, and elimination of lights and instruments make generator and battery unnecessary.

IN NEW PRODUCTS









Horizontally opposed engine . . .
has 4 cylinders, 53.5-cu in. displacement, develops 16 net brake hp. The integral crankcase-cylinder block is basically an open-box structure--see (A) below. Machined surfaces on top and bottom of the box accommodate intake manifold and oil pan. Crankshaft runs in two lead-bronze bearings. Front bearing is inserted in crankcase wall; rear bearing is mounted in a crankshaft bearing plate that also supports the cable start-mechanism.

Lubrication for connecting rod and main bearings is provided by drilled passages in crankshaft. Two overhead valves per cylinder are controlled by the camshaft through pushrods and rocker arms. Rocker-box lubrication is provided by oil under pressure. It flows through the hollow pushrods to the rocker-arm shafts and returns to crankcase by way of the pushrod housing. Oil pressure is supplied by a pump mounted on front end of camshaft. An extension of the pump shaft operates the diaphragm-type fuel pump. Magneto and camshaft are chain-driven directly off crankshaft. Engine-cooling air is supplied by a fan; sheet metal shrouds that enclose crankcase and cylinders direct the air flow. Fan drive is by V-belt from a crankshaft extension and pulley. Flywheel and single-plate clutch are bolted directly to crankshaft.

Major engine components . . .
are sand-cast SAE 322-T6 aluminum. Chilled cast-iron cylinder liners are inserted into the cylinder block bores (A), which are heated to 350 F, then honed to size. Cylinder heads (B) have cast-iron valve guides; spark plug hole has coiled insert; cast-iron valve seats are used. Accessory case housing and drive bracket (C and D) provide mounting for the cooling fan and all accessories. The higher cost of aluminum is partially offset by ease of machining these components and possibility of using permanent mold castings or injection moldings for large-scale production. Injection molding would result in further savings by eliminating many machining operations and reducing scrap.

for Streamlining and Weight-saving

TAP the RESERVE STRENGTH in METAL PARTS

A stress analyst tells why aircraft design has been going beyond the yield strength of a material—and getting away with it. Here also are his charts and formulas to cut down time when computing how far you dare go in bending, and a sample problem illustrating the method.

DOMINIC J GRAZIANO
Senior Dynamics Engineer, Republic Aviation Corp, Farmingdale, L. I.

SYMBOLS

A = Area of a cross section, in.^{2}
C = Distance from neutral axis to extreme fibers, or half the total height of section, in.
e = Unit elongation corresponding to yield stress = 0.002 in./in.
I = Area moment of inertia, about the neutral axis, in.^{4}
K = Distance from neutral axis to point where yield stress occurs, divide by C; $K = y/C$
L = Beam length, in.
M = Bending moment, resistance or applied, in.-lb
M_y = Bending moment to cause yield of extreme fibers, in.-lb
y = Distance from the neutral axis to a differential area, in.
σ_m = Max stress at the extreme fibers; σ_y = yield-point stress; σ_u = ultimate stress, psi
δ = Vertical deflection caused by permanent deformation in beam cross-section, in.

How far can you design past the yield strength of a structure? The incentive to do so—and still keep this side of collapse—is tempting because here is a region where you begin tapping reserve strength of the material. This brings benefits from higher strength-weight ratio, reduction in costs, and streamlining. Such results are obviously valuable to the aircraft industry and it has been leading the way in getting more out of a material by pushing nearer to the forbidden area of ultimate strength.

A hindrance in this region is that standard stress-deflection equations no longer hold true. But new calculating aids can be substituted. Here are such derived equations and simplified design curves that will predict the maximum stress, moment and permanent deformation involved when pushing past the yield strength of a material under pure bending loads. The equations and curves can also be put to work computing the power required to bend materials permanently or stamp out shapes in presses.

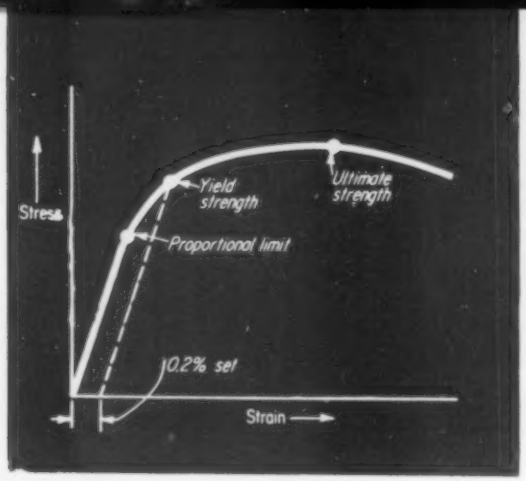
THE PLATEAUS OF STRESS

A structure does not rupture under steady state stresses until ultimate strength of the material is reached. Before that point, there are three sectors on the stress strain curve, Fig. 1, where design can operate.

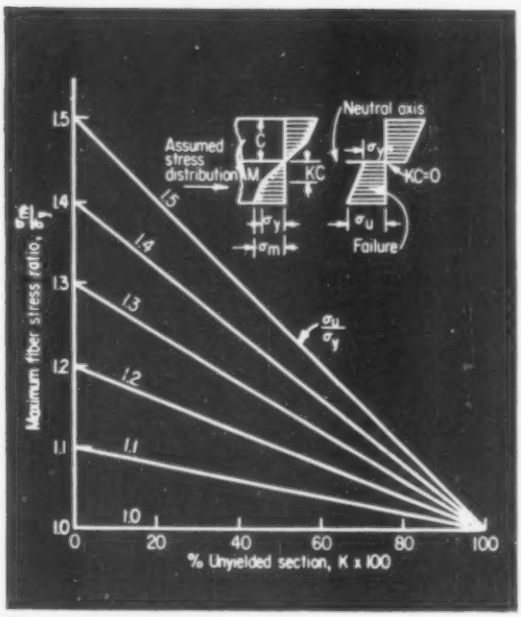
The proportional limit. This is the point of completely safe return. Deflection mounts in a straight line with stress. When load is relieved, the deflection drops proportionately and disappears entirely at no load.

The yield strength. This is a point of relatively safe return and is commonly used in design when a very slight deformation is not a drawback. From proportional limit to yield strength, deflection begins increasing disproportionately until there is an abrupt change of slope in the curve at the yield point. And when stress is relieved, the structure retains a small amount of deflection.

But many materials do not show a definite yield point for marking yield strength. Therefore an arbitrary point



1 Stress-strain Curve



2 Stress Relationships

is selected. To find it, a 0.2% offset line is usually drawn parallel to the straight-line portion of the stress-strain curve until it meets the curve. This point corresponds to a definite amount of permanent set, 0.2% of the original length of the material. For example, for a 1-in. bar it would be 0.002 in.

Between yield and ultimate strengths. This is where the aircraft industry has been taking design in the last few years. Here, if the structure is subjected to the maximum load conditions there will be a definite amount of permanent deformation after unloading. A rule-of-thumb often employed by the author is to stay within a stress limit at which 25% of the cross-section of the beam or structure will take a permanent set.

But regardless of how far you do go, value of the following design equations lies in that they tell how much permanent deformation you will get, where you are on the stress-strain curve as you enter the plastic range, and how far you are from failure.

EXAMPLE—THE CURVES AT WORK

A simply supported beam is to support a 6200-lb load at its center. Beam section is circular, of 2 in. dia. Beam length is 8 ft, $\sigma_u = 180{,}000$ psi, $\sigma_y = 138{,}500$ psi.

What is the: (1) amount of permanent set that may occur, (2) percent of section depth that yielded, (3) percent of beam length subjected to yield, (4) max fiber stress, (5) max allowable moment for the beam, (6) load that will cause failure, (7) margin of safety?

Bending moment at the center:

$$M = \frac{PL}{4} = \frac{6200\ (8)\ (12)}{4} = 149{,}000 \text{ in.-lb}$$

Section Modulus:

$$Z = \frac{I}{C} = \frac{\pi r^3}{4} = 0.785 \text{ in.}^3$$

Yielding Moment:

$$M_y = \sigma_y Z = 138{,}500(0.785) = 108{,}600 \text{ in.-lb}$$

Stress Ratio:

$$\frac{\sigma_u}{\sigma_y} = \frac{180{,}000}{138{,}500} = 1.3$$

Moment Ratio:

$$\frac{M}{M_y} = \frac{149{,}000}{108{,}600} = 1.37$$

From Fig. 4, for $\sigma_u/\sigma_y = 1.3$ and a moment ratio of 1.37, K is 67% or 0.67.

SOLUTIONS:

(1) Permanent set $= \dfrac{eL^2}{4C}\left(\dfrac{1-K}{K}\right)$

$$= \frac{0.002\ (8 \times 12)^2}{4(1)}\left(\frac{1-0.67}{0.67}\right)$$

$$= 2.26 \text{ in.}$$

(2) The % of section yielded is $100 - 67 = 33\%$.

(3) Point x along the length of beam where the yielding moment (108,600 in.-lb) occurs (measured from either end) is found from the equation $M_y = Px/2$. Thus

$$x = 2(108{,}600)/6{,}200 = 35 \text{ in.}$$

The percent beam length that yielded is

$$100(48 - 35)/48 = 14.6\%$$

(4) From Fig. 2 for $K = 67\%$, $\sigma_m/\sigma_y = 1.1$ and $\sigma_m = 1.1\ (138{,}500) = 152{,}000$ psi.

(5) Maximum allowable moment, or the moment that will cause failure for the configuration, is the value of M corresponding to $K = 0$; thus, from Fig. 4 the moment ratio is 2 for this case and $M_u = 2\ (108{,}600) = 217{,}200$ in.-lb.

(6) Load that will cause failure is

$$P = \frac{M4}{L} = \frac{217{,}200(4)}{8\ (12)} = 9{,}000 \text{ lb.}$$

(7) Margin of safety is $= \dfrac{217{,}200}{149{,}000} - 1 = 0.46.$

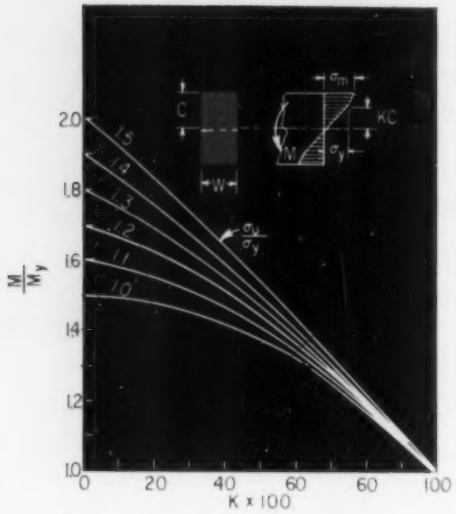
It is assumed that the bending-stress distribution is as shown in Fig. 2, that the yield point is at a distance KC from the neutral axis, and that the max stress, σ_u, occurs at a distance C.

As the applied moment is increased the resisting moment must balance it for equilibrium; thus, more of the section yields, and unyielded portion, KC, decreases.

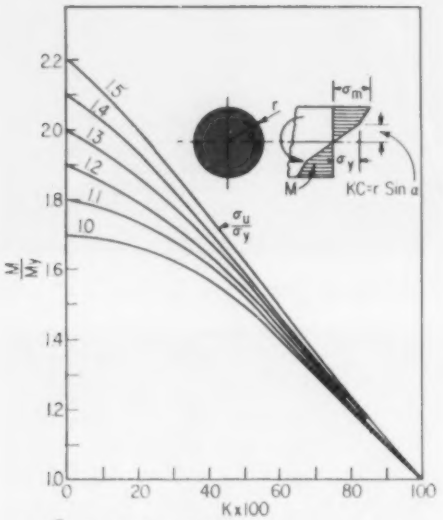
When ultimate stress occurs at the outer fiber, the value of K is assumed to approach zero. In the elastic

FAMILY OF CURVES SHOWS HOW MOMENTS AND STRESSES AFFECT YIELDING

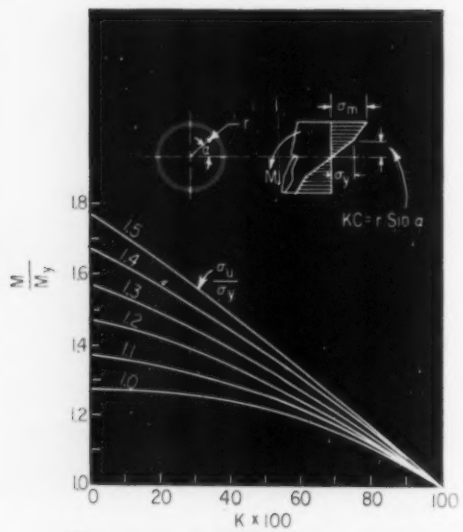
(M/M_y = moment ratio; K x 100 = % unyielded section)



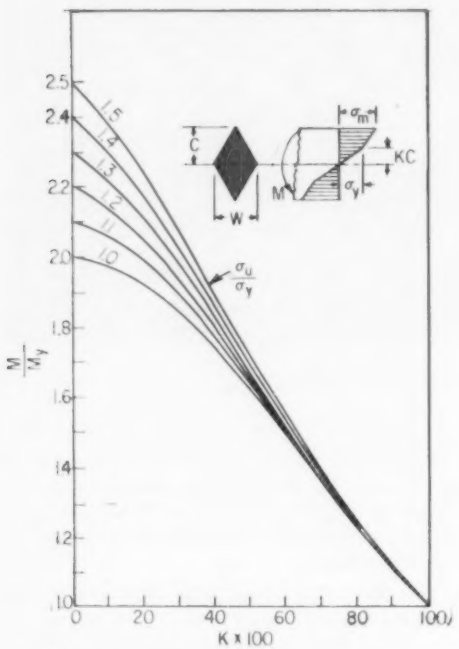
3 Rectangular Section



4 Circular Section



5 Thin-walled Rings



6 Diamond Section

range, as the moment is increased, the slope of the stress pattern relative to the neutral axis decreases. This is also true for the unyielded portion of the stress pattern here. The plastic portion, however, is assumed to have a constant slope for increasing load.

Once the stress distribution is known for a given cross-section, the forces and moments causing the stress can be summed up from this equilibrium equation:

$$M = {}_A\!\int \sigma y \, dA$$

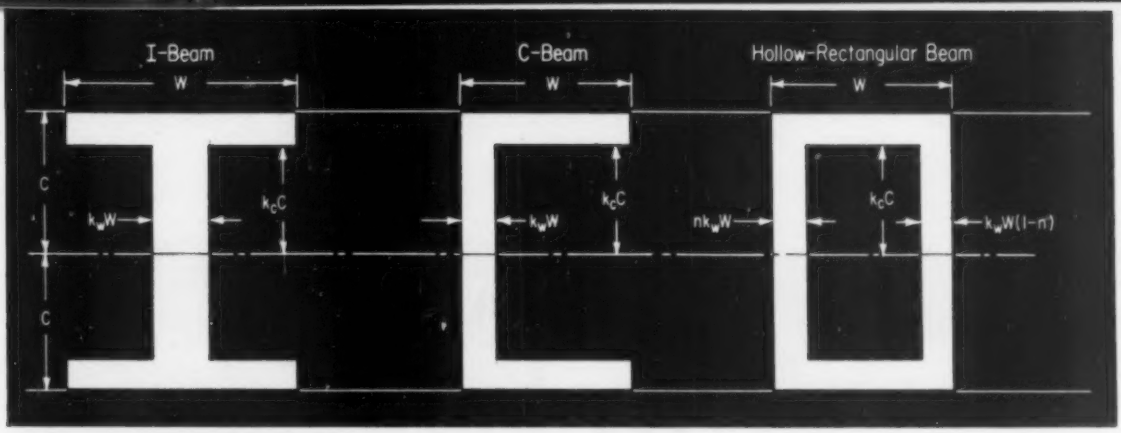
CURVES AND EQUATIONS

The curves in Figs. 3 to 6 are the results of determining dimensionless ratios from the derived expressions. In each figure, a family of curves for values of σ_u/σ_y ranging from 1 to 1.5 is plotted. The equations are given below:

Rectangular Cross Section—Fig 3

$$M_y = \sigma_y\left(\frac{2}{3}\,WC^2\right)$$

$$\frac{M}{M_y} = \frac{3}{2} - \frac{1}{2}K^2 + \left(\frac{\sigma_u}{\sigma_y} - 1\right)\left(1 + \frac{1}{2}K^2 - \frac{3}{2}K\right)$$



7 Dimensional Symbols . . .
as applied to equations derived for three beam configurations.

This equation is the simplest to derive, and is usually as far as the subject of plastic deformation for pure bending is carried by authors. Some papers have gone farther, assuming a trapezoidal stress distribution. But this will understate the extreme fiber stress, especially for the early stages of yield, i.e. where K is in the range of 0.5 to 1.0.

Note that in the above equation as well as those which follow, when $\sigma_u = \sigma_y$ then $\sigma_u/\sigma_y = 1$, the last term drops out, and your curve is for materials which cannot be stressed beyond the yield strength. An increase in load will decrease the value of K.

Circular Section–Fig. 4

$$M_y = \sigma_y\left(\frac{\pi}{4} r^3\right) \qquad K = \sin\alpha \qquad C = r$$

$$\frac{M}{M_y} = \frac{2\alpha}{\pi \sin\alpha} + \frac{2}{3\pi}\cos\alpha\,(2\cos^2\alpha + 3) + \left(\frac{\sigma_u}{\sigma_y} - 1\right)\left[1 - \frac{2\alpha}{\pi} - \frac{2\sin\alpha\cos\alpha}{3\pi}\,(2\cos^2\alpha + 3)\right]$$

This equation is written in polar form for a more direct physical significance and for simplicity.

Thin-walled Rings–Fig. 5

$$M_y = \sigma_y(\pi r^2 t) \qquad K = \sin\alpha \qquad C = r$$

$$\frac{M}{M_y} = \frac{2}{\pi}\left[\frac{\alpha}{\sin\alpha} + \cos\alpha + \left(\frac{\sigma_u}{\sigma_y} - 1\right)\left(\frac{\pi}{2} - \alpha - \sin\alpha\cos\alpha\right)\right]$$

When the ratio of inner to outer radius approaches 1, the thin-walled ring approximation can be used.

Diamond Section–Fig. 6

$$M_y = \sigma_y\left(\frac{WC^2}{6}\right)$$

$$\frac{M}{M_y} = 2 - K^2(2 - K) + \left(\frac{\sigma_u}{\sigma_y} - 1\right)(1 + K)(1 - K)^3$$

I-beams, C-beams, Hollow Rectangular Sections–Fig. 7

Only the equations are given here as the curves are still in the process of development. They will be published at a later date. Fortunately, the same equations can be made to apply equally to all three sections.

To use the equations, the dimensionless ratios of k_c, k_w and k_f must be in accordance with those shown in Fig. 7. Also, the equations employ the ratio R which compares the section modulus of any of these three beams with that of a solid rectangular section. Thus for the I-beam, C-beam or hollow-rectangular beam:

$$R = \frac{1}{1 - k_c^3(1 - k_w)}$$

Ratio R can vary between zero and unity for all possibilities when considering curve-data presentation.

The stress distribution has two possibilties: (1) K ranging from zero to k_c, and (2) K ranging from k_c to 1. Two equations are needed to describe the entire range:

$$M_y = \frac{2}{3}\sigma_y W C^2/R$$

(1) For the range: $0 \leq K \leq k_c$

$$\frac{M}{M_y} = R\left\{\frac{3}{2}\left[1 - k_c^2(1 - k_w)\right] - \frac{1}{2}k_w K^2 + \left(\frac{\sigma_u}{\sigma_y} - 1\right)\left[1 + k_c^2(1 - k_w)\left(\frac{3}{2}K - k_c\right) - \frac{3}{2}K\left(1 - \frac{k_w K^2}{3}\right)\right]\right\}$$

(2) For the range: $k_c \leq K \leq 1$

$$\frac{M}{M_y} = R\left\{\frac{3}{2} - \frac{k_c^2}{K}(1 - k_w) - \frac{1}{2}K^2 + \left(\frac{\sigma_u}{\sigma_y} - 1\right)\left[1 - \frac{3}{2}K\left(1 - \frac{K^2}{2}\right)\right]\right\}$$

PERMANENT SET

After the load is removed, a beam which exceeded the yield stress will show a permanent deformation at point of maximum stress. For a simple beam with a concentrated load in the middle, the deformation is:

$$\delta = \frac{eL^2}{4C}\left(\frac{1 - K}{K}\right)$$

For a cantilever with load at end, deformation will be four times that of a simple beam of equal length.

EDITOR'S NOTE: For another second look at established stress concepts see "How Wrong Can Elastic Constants Be?", Jan 6, p 68. The article shows why even precise testing methods will give variations in material constants.

Also helpful will be "Stress Corrosion in Metals," Aug 4, p 56. The article explains why stress plus chemical environment can make it tough for some alloys to resist cracking.

PNEUMATICS:

Safeguarding the AIR SUPPLY

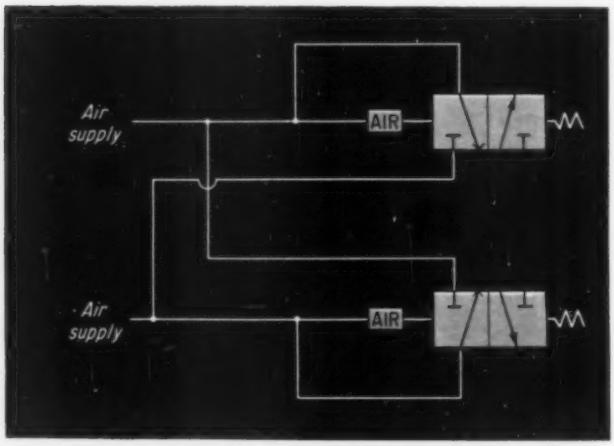
A breakdown will be less expensive and dangerous if emergency equipment steps in, allowing time for repair. Author illustrates three ways to do it, also shows how standby air can do a non-emergency job—start up a gas turbine.

E. L. HOLBROOK, *Industrial Products Div, Westinghouse Air Brake Co*

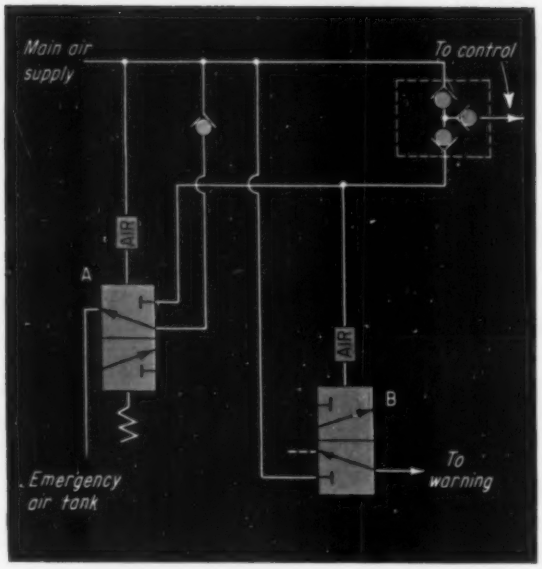
Any control system is only as reliable as the power behind it. This is as true with air as with oil or electricity, and explains why special safeguards are needed for faithful operation of the air supply.

Their job is to take over when a pneumatic-control system is heading toward serious trouble. True, the system contains some elements of self-protection. It is the function of pressure regulators and reducing valves to maintain fairly constant output pressures despite fluctuations or temporary loss of air at the input. Also, checks and other control valves pass flow in only one direction, therefore help keep the air working despite upstream losses. And tanks, piping and other storage components of the system usually furnish sufficient compressed air to act as temporary supply when there is a gradual loss of pressure.

But this is not always adequate and



Mutual-backup arrangement . . .
is one way to assure adequate air, but requires two separate supplies. Either air relay in the diagram will operate if its controlling pressure drops below a set low value. This immediately starts air flow from the other supply and returns pressure to normal. Simultaneous failure of both supplies is unlikely, and one supply can counteract any reasonable leak in the other . . . giving repairmen time to fix it.



Emergency supply . . .
is a tank of air available when needed. It is good at full flow for limited time—or for long time with limited flow. But it could also be a special system with its own full-size compressor if greater assurance of continuous operation is needed.

In normal operation, main-supply pressure holds air relay A in downward position, completing circuit from main supply to emergency. This keeps emergency tank charged. Check valves provide flow path to control circuit at right. When main air supply falls to unsafe level, relay A is triggered and emergency air immediately augments supply—eventually taking over job of feeding the control. Pressure to top of relay B now actuates warning circuit which gets its air supply by bleeding down the main supply header. This warning, if it is an air whistle, will stop when pressure drops towards zero.

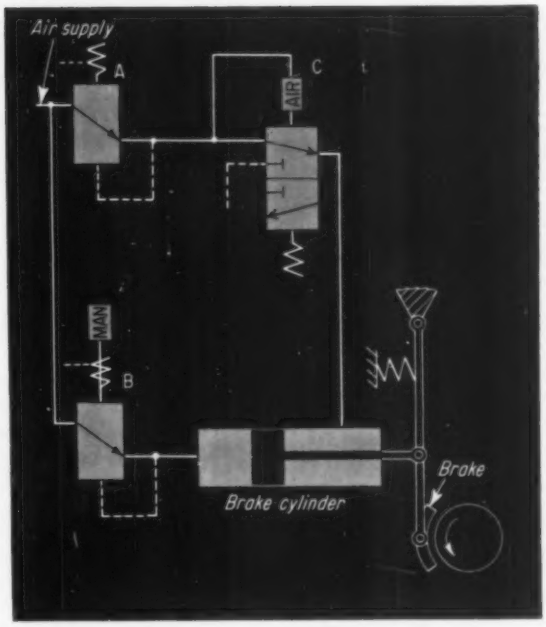
it runs the risk of shutdown expense higher than an investment in reliable standby safeguards. Protection should be considered in terms of danger to personnel caused by possible malfunction, value of machinery that may be damaged, and production loss resulting from a crippling breakdown.

Emergency measures benefit from the fact that an air system generally does not fail abruptly or completely. Excessive leakage will slow it down, and this can sound off a warning to the operator, allowing him time to inspect the system and make necessary adjustments or repairs.

The type of warning and degree of protection needed pending repairs will vary, depending on the application. Illustrated on these two pages are three methods for safeguarding. A fourth, in which the standby air-supply technique is adapted to serve a normal functional purpose, is shown on next page.

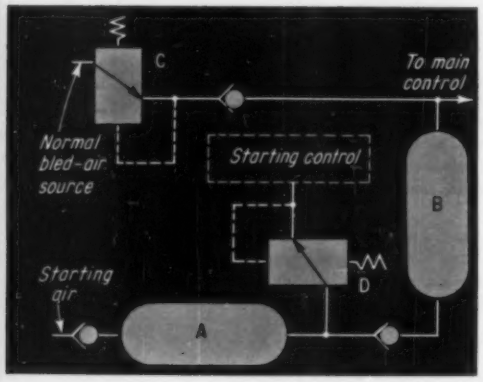
Of the three emergency methods, one requires an additional, continuous air supply; the second needs only a temporary secondary supply; the third uses no auxiliary air, but halts the operation automatically.

(continued on next page)



Fail-safe brake . . .
is possible without auxiliary source of air. Brake is mechanically loaded in locking direction, and released only if pressure from air relay C is applied to right-hand side of cylinder. Manually adjusted pressure regulator B can control braking force by applying controlled pressure to left side of cylinder. Balance of these two pressures plus spring on brake arm gives any desired braking. Failure of air supply or dangerously low pressure (less than set on reducer A will trip air relay. Right side of cylinder is then vented, and spring applies emergency braking force.

AIR SUPPLY (cont.)



Standby-air method . . . can also serve a non-emergency purpose. In application above it supplies startup air—thereafter, control air is bled from the operating equipment through reducer C.

Diagram shows air bled from a gas turbine (at high-pressure-air portion of its flow path) to pressurize main control. At startup, however, this air is not available, and a small motor-driven air compressor is needed to fill tanks *A* and *B*. Triggering the starting control will allow stored air from *A* to flow through reducing valve *D*, initiating starting sequence and "firing" the turbine. Tank *B* maintains control pressure until turbine is up to speed and takes over. Surplus pressure at start is recommended, because losses reduce pressure in *B* quickly.

EDITOR'S NOTE: Power with air has been gaining popularity because of improved control and reliability.

"Fundamentals of Pneumatic Control," Mid-Oct '56, p J18, gives 13 typical air circuits for sequencing air cylinders; "Design of Pneumatic Relay Circuits," Mid-Oct 56, p J8, uses air-electric analogy to evaluate time lags, safety, and sequencing; "Compressed Air for Push or Pull," Oct 14 '57, p 72, shows how air valves and cylinders can be used for sequence operations; "Calculating Time Lag of Hydraulic and Pneumatic Valves," June '56, p 158, gives formulas and curves for determining valve operating time and speed of response: "Switching-logic Functions," Aug '57, p 196, explains the AND, OR, NOT, and MEMORY concepts; and "Valve With a Memory," May 26 '58, p 76, applies logic to pneumatic control.

Details in the construction, operation, and application of 2-way, 3-way, 4-way, and other solenoid-operated valves for pneumatic and hydraulic service are discussed in "Solenoid Valves for Fluid Directional Control," July '55, p 162.

YOUR PLAN for '59...

Modernize Engineering

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WHY MODERNIZE

A special report in the October 6th R & D Issue will marshall facts to help you prove the need for modernization of your product design and development function now.

- **How to calculate what the R & D investment should be.**
- **Minimum needs for an engineering laboratory.**
- **What a model shop can save in development time.**
- **Values in good engineering library.**
- **Cost-saving potentials in new methods of drawing reproduction.**

Here will be ideas, data and facts to help you measure present effectiveness and justify modernization of your engineering department.

HOW TO MODERNIZE

The following week, in the October 13th Design Issue, another special report will provide specific information on modern drafting equipment, organization of an efficient engineering laboratory, how to set up a library, and what should go into a model shop.

Together, the two reports will be a working handbook to answer in detail both why and how the engineering department must be modernized for effective product development and design in '59.

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Plan '59 *Modernize Now for growth and profits*

A special report from McGraw-Hill to American business executives

why it pays to depend

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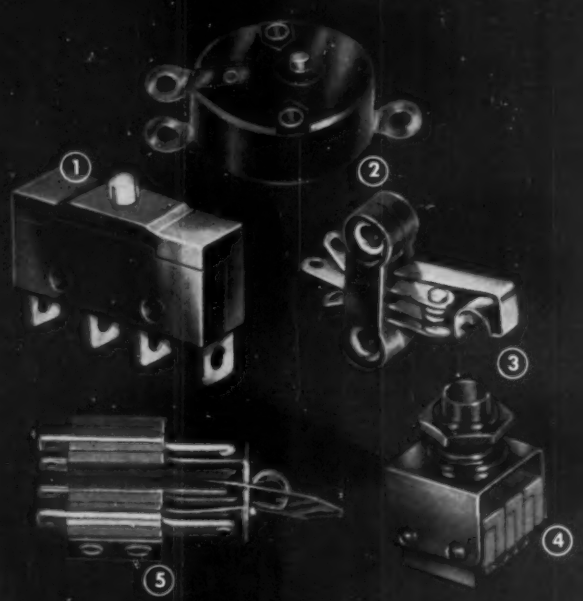

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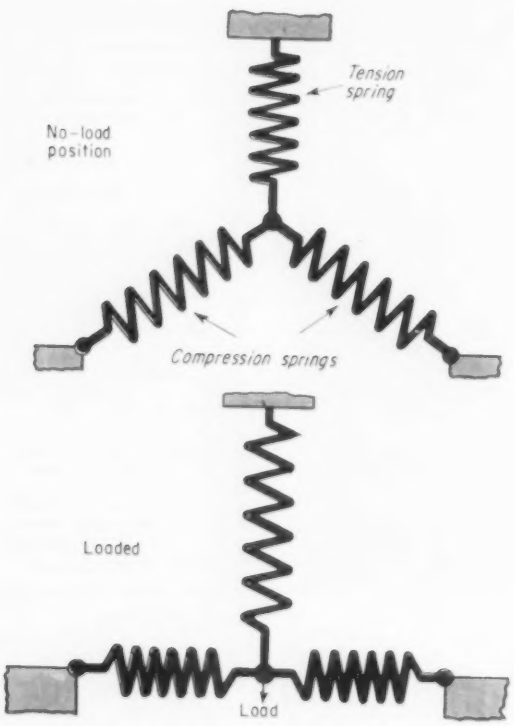
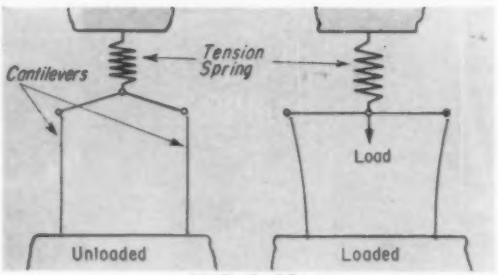
VIBRATION ISOLATORS

Need a buffer between vibrating machinery and the surrounding structure? These isolators, like a capable fighter, absorb the light jabs and stand firm against the forces that are haymakers.

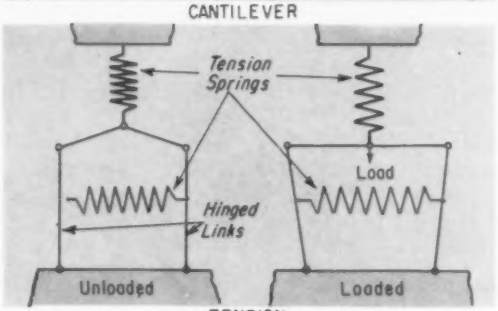


1

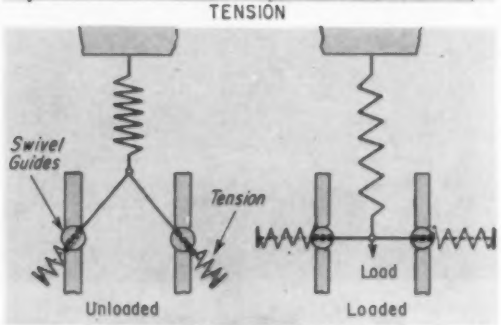
Basic spring arrangement . . .
has zero stiffness, is "soft as a cloud" when compression springs are in line, as illustrated in the loaded position. But change the weight or compression-spring alignment, and stiffness increases greatly. Such a support is adequate for vibration isolation because zero stiffness gives a greater range of movement than the vibration amplitude—generally in the hundredths-of-an-inch range. Arrangements shown here are highly absorbent when required, yet provide a firm support when large force changes occur. By contrast, isolators depending upon very "soft" springs, such as the sine spring, are unsatisfactory in many applications—they allow large movement of the supported load with any slight weight change or large-amplitude displacing force.



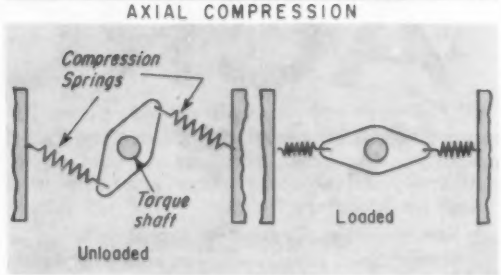
CANTILEVER



TENSION



AXIAL COMPRESSION



TORQUE

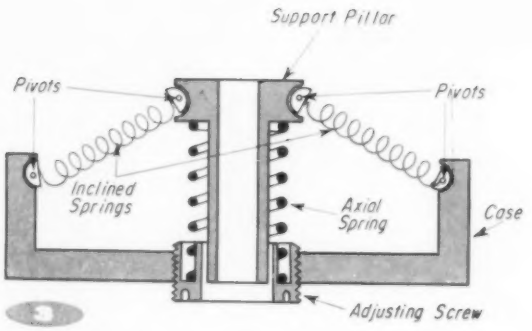
2

Alternative arrangements . . .
illustrate adaptability of basic design. Here, instead of the inclined, helical compression springs, either tension or cantilever springs can serve. Similarly, different types of springs can replace the axial, tension spring. Zero torsional stiffness can also be provided.

with ZERO STIFFNESS

FROM ENGLAND

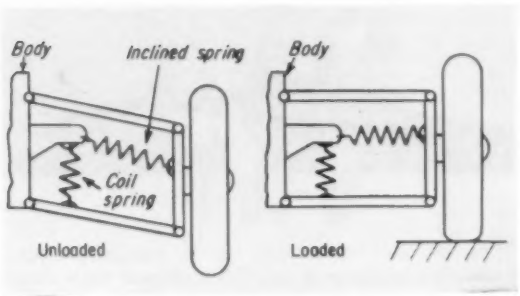
This new form of spring arrangement is described in "Supports for Vibration Isolation," a British Aeronautical Research Council paper by W. G. Molyneux. He explains and illustrates the basic arrangement, as well as alternatives. From his paper come the applications shown here, together with a brief description of the principles involved.



3

General-purpose support . . .
is based on basic spring arrangement except that axial compression spring is substituted for tension spring. Inclined compression springs, spaced around a central pillar, carry the component to be isolated. When load is applied, adjustment may be necessary to bring inclined springs to zero inclination. Load range that can be supported with zero stiffness on a specific support is determined by the adjustment range and physical limitations of the axial spring.

Various applications . . .
of the principle to vibration isolation show how versatile the design is. Coil spring (4), as well as cantilever and torsion-bar suspension of automobiles can be all reduced in stiffness by adding an inclined spring; stiffness of tractor seat (5) and, consequently, transmitted shocks can be similarly reduced. Mechanical tension meter (6) provides sensitive indication of small variations in tension: as a weighing device, for example, it could detect small variations in nominally identical objects. Nonlinear torque meter (7) provides sensitive indication of torque variations about a predetermined level.



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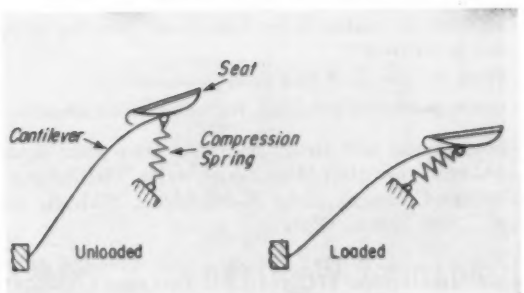

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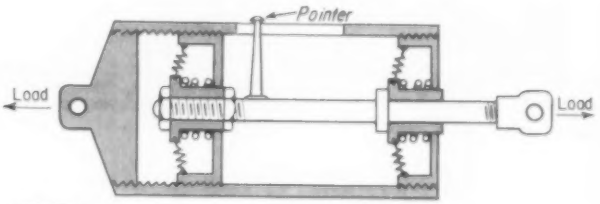

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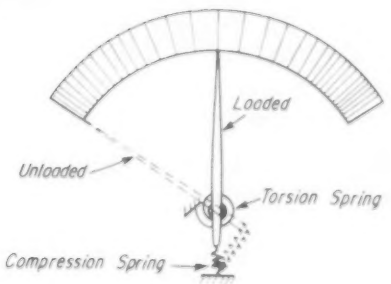
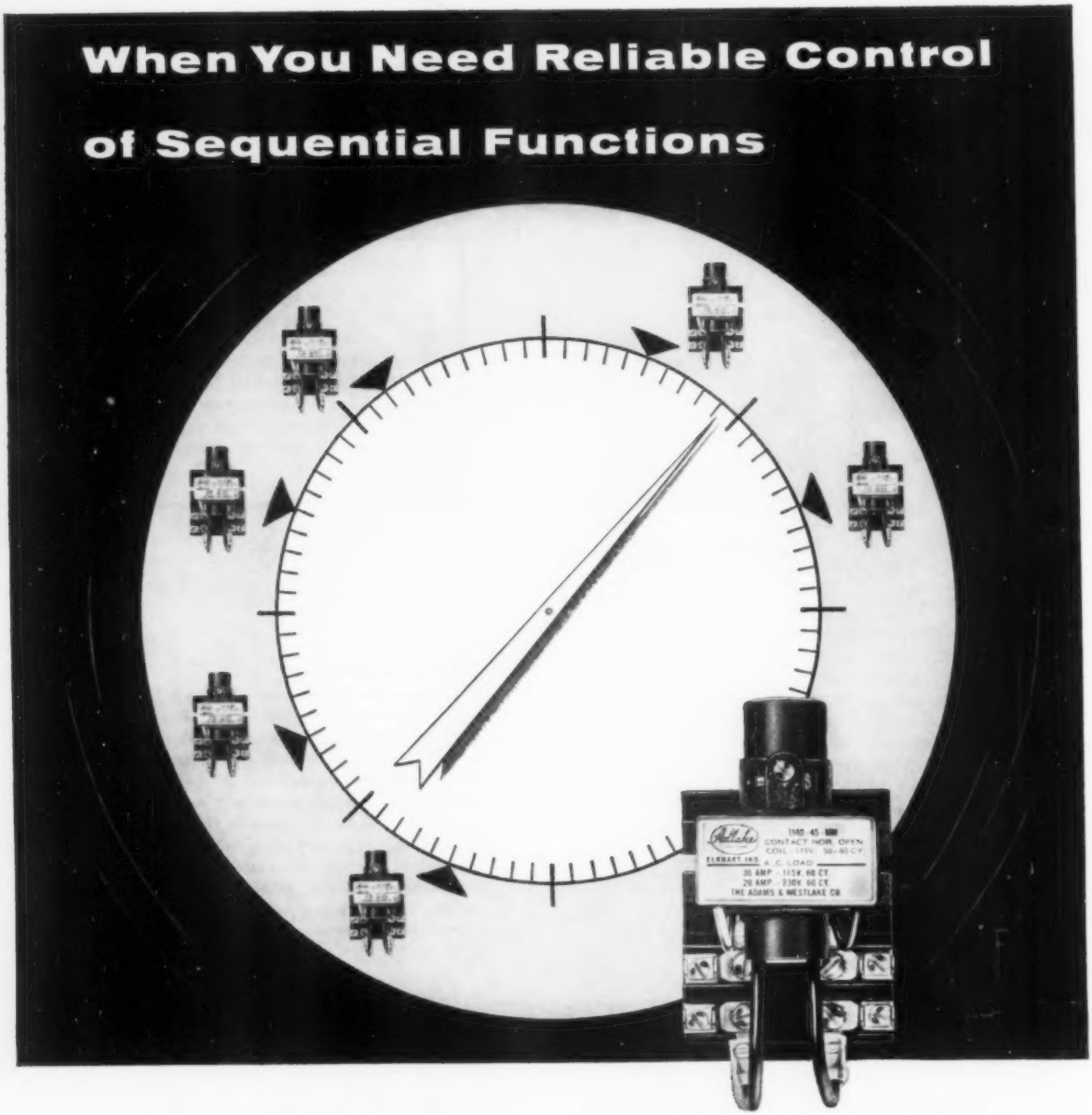


7

When You Need Reliable Control of Sequential Functions



you need Adlake mercury-to-mercury relays

From sensitive laboratory use to rugged locomotive application, Adlake relays have proved their dependability and versatility. Here's why:

- **Perfect snap action—no pitting, burning or sticking**
- **Hermetically sealed at the factory—no intrusion of dust, dirt or moisture**
- **Fixed, tamper-proof time delay characteristics**
- **Quiet, chatterless operation. No maintenance whatever.**

Our engineers will gladly help you solve your control problems—no obligation. Just write The Adams & Westlake Company, 1169 N. Michigan, Elkhart, Indiana...New York...Chicago

The Adams & Westlake Company Adlake

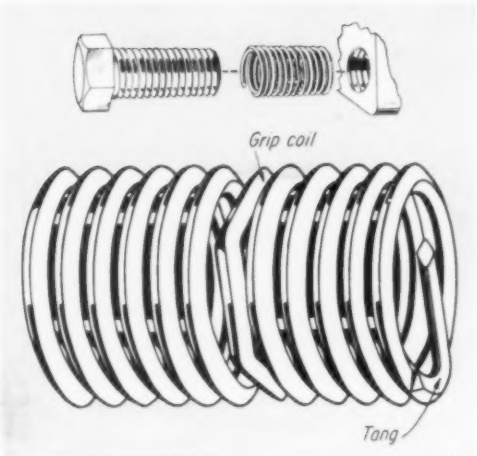
NEW YORK ELKHART, INDIANA CHICAGO

Established 1857

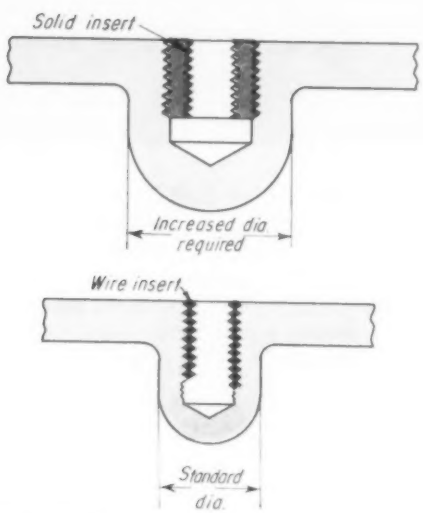
these design features, diagrams and test results will help when it becomes necessary to take . . .

A LOOK at WIRE INSERTS

HARKNESS W CRAM
Technical Standards Manager
Heli-Coil Corp, Danbury, Conn.



Self-locking insert . . .
contains a grip-coil, which works like a series of flexible beams. These cause a locking effect on thread flanks when screw is introduced into insert. Power tools are available for insert-driving.



Boss diameters . . .
need not be increased from standard sizes when wire inserts are called for, rather than solid ones.

The four chief design areas where wire-thread inserts can be employed are:

1. Give more stripping strength to thread. (This increase is proportional to increased area, i.e. to area of insert-thread compared with that of the smaller inside thread.) This way, advantages of base materials, originally selected for other reasons than thread strength, can be retained.
2. Provide self-locking features. (No external locknut or lock-washer is required.)
3. Solve problems of thread galling in such metals as aluminum, magnesium and titanium.
4. Repair stripped holes.

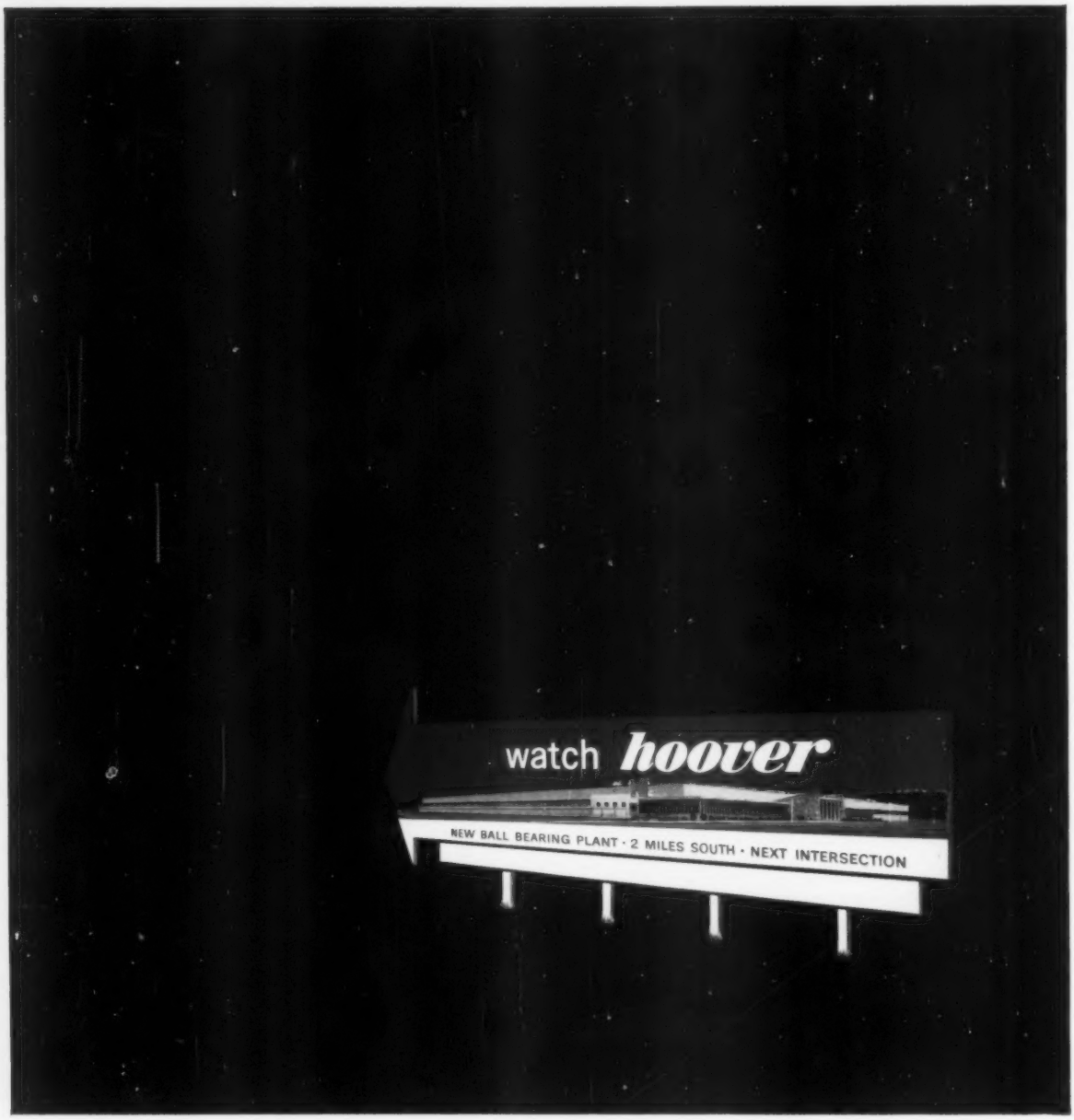
An example is the Heli-Coil wire insert, a helically wound coil of diamond-shaped 18-8 stainless steel wire. When called for, these inserts can also be wound from phosphor-bronze.

The insert is assembled into a tapped hole with a special tool that engages the tang. After assembly the tang can be broken off. If not deep enough to interfere with the screw, however, it can be left on.

Special taps, required to cut the thread that receives the insert, are supplied by the insert manufacturer.

Tap-drill size is extremely important for proper insert performance. The recommended size, along with other assembly details given by the manufacturer, must be adhered to.

(Continued on page 57)



GOOD SIGN FOR BEARING BUYERS! On Michigan's famed Willow Run Expressway, signs like the one above point to the newly completed Hoover plant. Here, new equipment and modern techniques are skillfully utilized to produce increased quantities and additional types of America's *Quality* Balls and Bearings. Hoover has made these major improvements to provide better service for present customers . . . to serve more and more new customers. You are invited to write for complete information about Hoover products. Watch Hoover for future announcements of interest to bearing buyers.

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5400 South State Road, Ann Arbor, Michigan

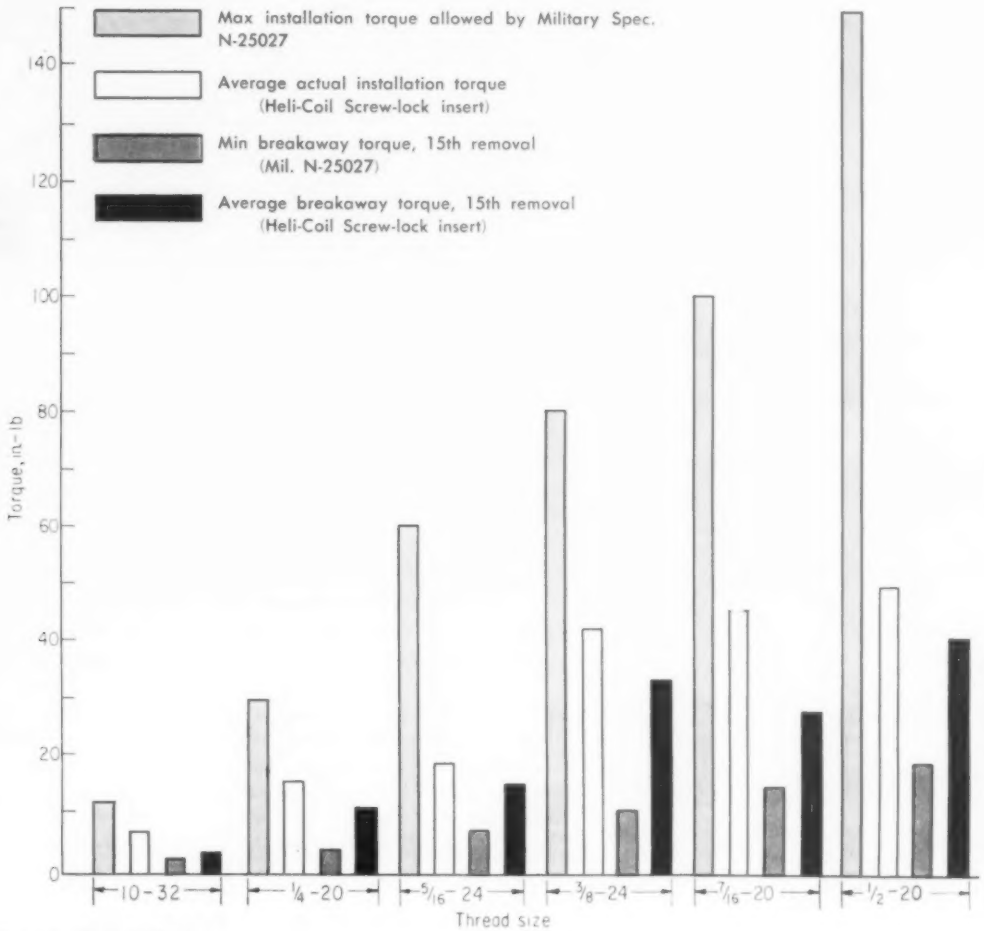
Los Angeles Sales Office and Warehouse: 2020 South Figueroa, Los Angeles 7, California

A LOOK at WIRE INSERTS (continued)

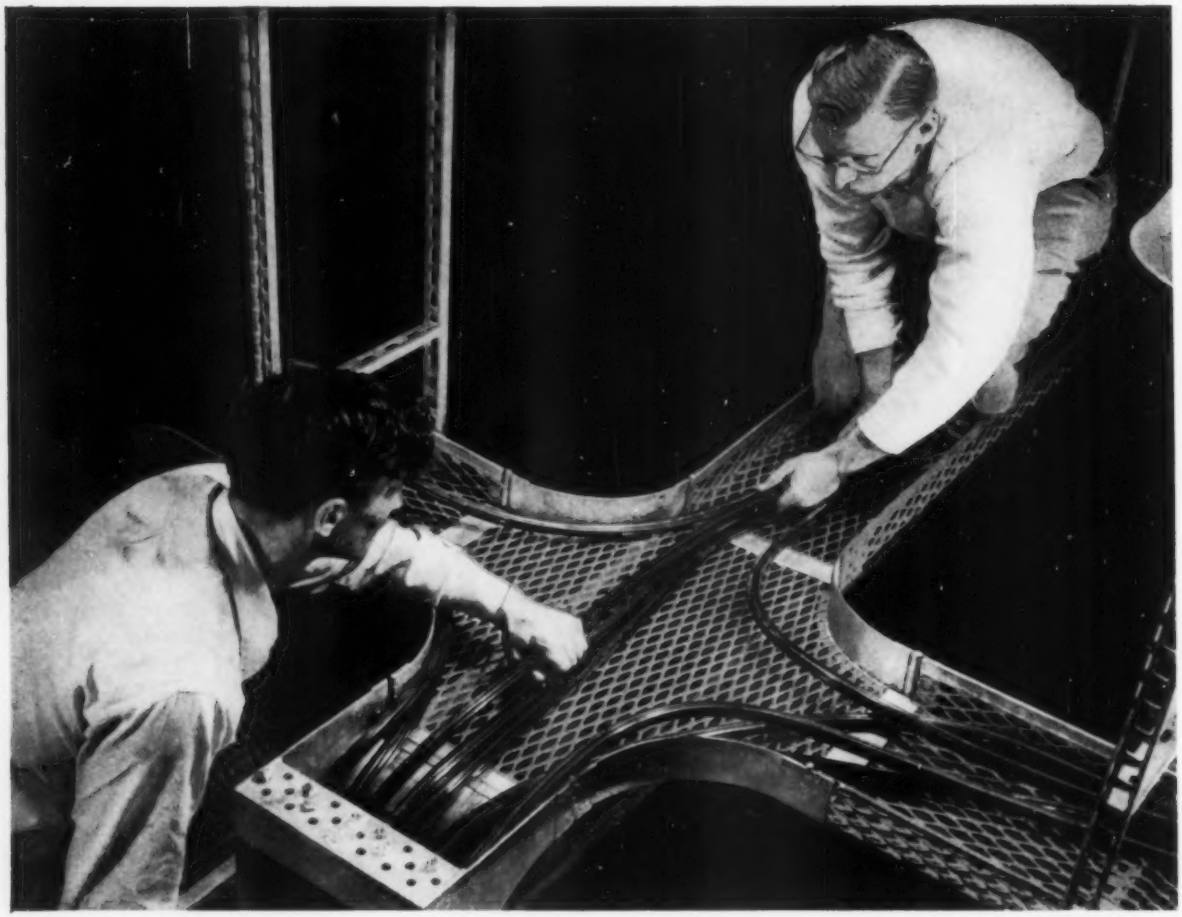
Test Results with Self-locked Wire Inserts

(In 2024T4 aluminum. Note that no thread stripping occurred; bolt always failed first.)

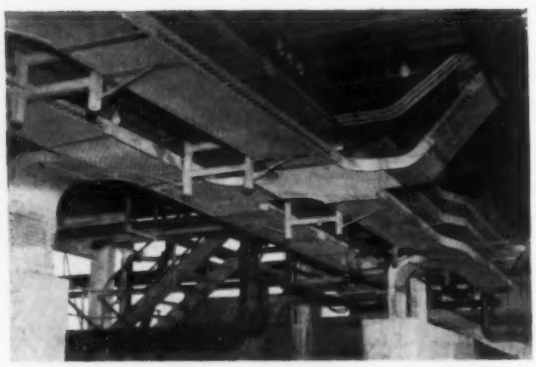
INSERT SIZE	TORSION			TENSION	
	Recommended Max Torque, in.-lb	Recommended Min Torque, in.-lb	Failure (bolt), in.-lb	Min Required Tensile Strength, lb	Failure (bolt), lb
10-24	40	20	75	1,800	2,800
1/4-28	75	60	220	4,000	5,750
5/16-18	90	75	300	5,800	7,750
3/8-24	190	175	640	10,200	13,500
7/16-14	257	240	1,010	11,750	17,750
1/2-20	690	480	2,040	18,500	25,750



Torque comparisons . . .
for wire inserts were based on 10 separate tests. Minimum or maximum values were not exceeded in averaged values. Inserts were in 2024T4 aluminum. In similar tests done at 500 F, max and min limits of military specifications were not exceeded in either 245T4 aluminum or 1018 steel.



Strong, lightweight cable troughs illustrate the versatility of expanded metal



An installation of expanded metal cable troughs, made by T. J. Cope Division, Rome Cable Corp., Collegeville, Pa.

To understand why Penmetal expanded metal has such widespread and diversified application, note the important benefits resulting from its use in T. J. Cope cable-supporting systems.

The extreme lightweight of expanded metal makes cable troughs easy to install . . . without costly structural supports . . . yet with plenty of strength to take the weight of the cables. The open mesh simplifies cable inspection and repair. Low cost means large quantities can be used economically.

Of course, your company may never want to build cable troughs. But, if you make any product demanding a mesh, you can profit from expanded metal versatility. Available in a wide variety of mesh sizes in carbon steel, aluminum, stainless steel and other metals – standard or flattened. Readily cut, shaped or welded.

Send for full information about Penmetal expanded metal. Ask for a copy of catalog 515-EM.

Penmetal

a name to remember

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General Sales Office: 40 Central Street, Boston 9, Mass.
Plant: Parkersburg, W. Va.
District Sales Offices: Boston, New York, Philadelphia, Pittsburgh, Chicago, Detroit, St. Louis, Dallas, Little Rock, Seattle, San Francisco, Los Angeles, Parkersburg

PM-194

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Water-thinned contact cement . . .

is nonflammable and said to give instant high-strength bonds between such surfaces as glass, hardboard, metal, decorative high-pressure plastics, and wood. Can be sprayed, brushed or roller-coated. Suitable for room-temperature application. Adhesive can be heat-reactivated where combining is not done same day as coating in assembly-line production. $3-3.50 per gal depending on quantity; available from stock. **Structural Products Div, National Starch Products, Inc, 750 Third Ave, NYC.**

Circle 1, Reader Service Card

Lubrication alarm system . . .

sends a signal if flow of lubricant in central lubricating system is interrupted for any reason. Installed at each terminal point of lubrication by cutting line and connecting fittings. Unit is then connected electrically to any desired audio, visual or mechanical warning device. Usable with any viscosity oil or synthetic lubricant and for pressures to 10,000 psi. Explosionproof units are available. **Manzel, 315 Babcock St, Buffalo 10.**

Circle 2, Reader Service Card

Rigid PVC plastics . . .

for high impact and for extreme chemical resistance can be extruded twice as fast as conventional rigid PVC compounds. Compounds are free-flowing and said to have run as high as 100% faster than similar compounds. Good gloss characteristics are reported on contours and sheet for vacuum forming. QGD-5020 in extruded form is said to have an Izod impact strength in the range of 20 to 30 lb/in. Materials are suggested particularly for extruded pipe and contour applications. Both compounds are available in commercial quantities at 42½¢ per lb in truckload lots. **Bakelite Co, Div of Union Carbide Corp, 655 Madison Ave, New York 21.**

Circle 3, Reader Service Card

Quieter Impeller Takes Less Power

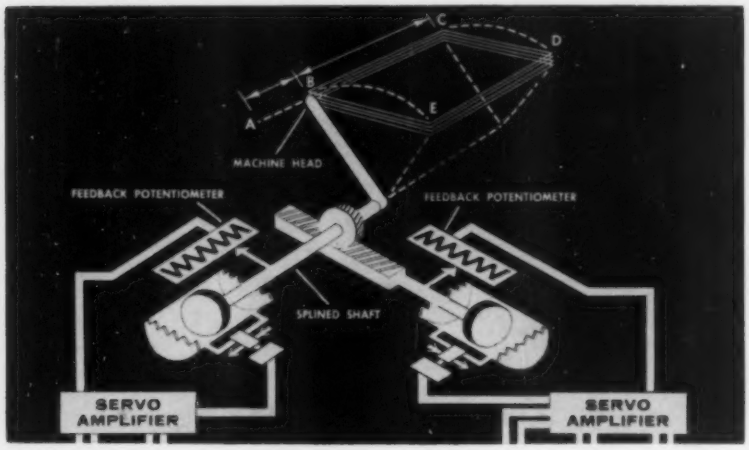
This mixed-flow impeller is designed to operate in the range between axial fans and centrifugal blowers. Most generation of pressure takes place within the blade passages, and for this reason, performance is less dependent upon housing configuration. Space required is comparable with that of conventional impellers in common use today.

Impeller is composed of 19 contoured blades mounted between a curved inlet ring and back plate. The blades at the intake edge resemble the blades of an axial impeller and at the discharge edge those of a centrifugal impeller, resulting in a compound blade curvature.

Impeller will initially be produced in four sizes to cover the flow range 150 to 800 cfm. Over-all dimensions will be 9 x 3 in., 10 x 3½ in., 11¼ x 3¾ in., and 12⅝ x 4$\frac{7}{32}$ in. Price and delivery information not available. **Air Impeller Div, Torrington Mfg Co, Torrington, Conn.**

Circle 4, Reader Service Card

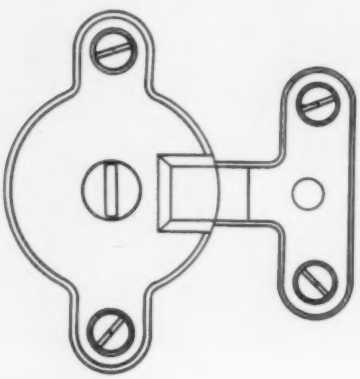
. . . CONTINUED ON PAGE 60



Automatic positioning system . . .

uses a direct-dialing analog programmer for point-to-point machine setup on short production runs in operations such as punching, drilling, inserting. System is said to be time-saving in programming for repetitive and symmetrical motion patterns. Variations can be made by resetting dials. Positioning is by electrohydraulic servo systems, capable of positioning speed of 0.2 sec per basic motion with positioning accuracy of 1 part in 1000. Modulated signal permits adjustment for longitudinal and transverse axis movements. Price for programmer and single-axis movement, about $6000. Delivery in about 4 mo. **CDC Control Services, Inc, 792 S. Warminster Rd, Hatboro, Penna.**

Circle 5, Reader Service Card



Joint fastener . . .

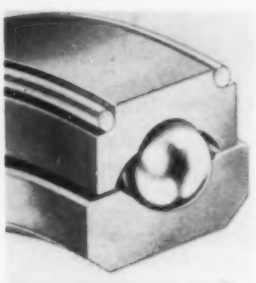
is available for either butt or right-angle assemblies. Screwdriver in slot rotates cam-like wedge, drawing panels tightly together and locking them into an assembly approximately 2¼ in. long when installed and locked. **Dynacon Corp, 5475 Bow Mar Dr, Littleton, Colo.**

Circle 6, Reader Service Card

Self-locking gear reducer . . .

is for rack and pinion, gear and pinion or friction-drive operations. Designed for operation by fhp motors to 1/9 hp at 2000 rpm, ⅛ hp at 3000 rpm or ¼ hp. at 4000 rpm, gear-reduction unit may be used for any operation in which electrical power must be converted to rotary or straight-line mechanical actuation. Available with transmission ratios of 52:1 and 27.5:1 with 6- or 8-tooth pinion. Transmitter measures 3 x 3½ x 1½. Lubricated for life. Prices range from $1.50 to $5.50. Delivery in 4 wk. **Huppower Div, Hupp Corp, 7450 Melville Ave, Detroit 17.**

Circle 7, Reader Service Card



Integral-shield bearings . . .

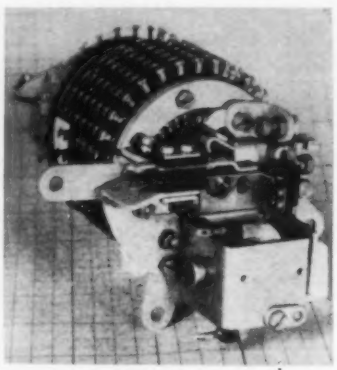
of thin-section design are made in 12 sizes with bores from ⅜ through 3 1/16 in. Shields are formed by extending lands of inner and outer rings to within a few thousandths of an inch of each other. Close-clearance annulus fills with lubricant, which functions as a seal. Deep-groove ball races have continuous shoulders. Full ball complements are used for max radial and two-directional thrust capacity. Alternate balls are undersized, acting as separators for the load-carrying balls and reducing torque in bearing. **Split Ballbearing Div, MPB, Inc, Lebanon, NH.**

Circle 8, Reader Service Card

Air-hardening alloy steel . . .

when cooled and tempered, develops tensile strength levels in 280,000-psi range (see Materials Briefs, Sept. 22 '58, p 12). Eliminates oil or salt quenching necessary for most other alloy steels to develop equivalent mechanical properties, and problems of huge quenching tanks to accommodate large parts. Metallic arc and inert arc welding tests showed that welded joint produced was equal to high-strength level of steel itself. Available in billets, blooms, bars, plates and sheets. **US Steel Corp, 525 William Penn Pl, Pittsburgh 30.**

Circle 9, Reader Service Card



Miniature stepping switch . . .

operates at speeds to 80 steps per sec on impulse drive (80% make-20% break) from a power supply of 24, 50 or 110 v dc. Up to 12 banks can be fitted, each having 30 individual contacts mounted in a complete circle. When only seven or fewer banks are required, a sequence switch can be fitted. Sequence switch-wiper steps once for each complete revolution of main wiper assembly. All wipers can be bridging or nonbridging. Weighs 17 oz. **Imtra Corp, 11 University Rd, Cambridge 38, Mass.**

Circle 10, Reader Service Card

Relay chatter . . .

is indicated by red neon lamp in this monitor when contact opening in excess of any selected time interval occurs. Ten durations can be selected, from 10 to 100

. . . *CONTINUED ON PAGE 62*

ANALYSIS — Kaydon studies every pertinent bearing requirement, such as speed, load, safety, operating and fatigue life factors.
DESIGN — Kaydon engineers bring an unequalled fund of knowledge and bearing design experience to your project.
MANUFACTURING AND TESTING — Complete, modern fabricating facilities . . . precision control of all quality factors.
custom engineering

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can prove or improve your product

Why penalize product performance success with "make-do" bearings? Kaydon's long experience points out that standard bearings often *won't do*, aren't always efficient or economical.

Kaydon engineers creatively design, develop and manufacture special, modified, and standard ball and roller bearings. All-new Kaydon "idea bearings" or modified types will help you *prove* your new product designs; *improve* your redesigns. Kaydon can incorporate millionth's-of-an-inch precision, light weight or super-rugged construction to exactly match the bearing to your application.

Send us sketches or scale prints of your bearing problem. *There's no obligation.*

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World's largest precision ball bearing (165") designed and built by Kaydon, rotates radar antennae.

World's thinnest radial ball bearing — Kaydon "Reali-Slim," 12.00" I.D., 12.500" O.D., .250" thick.

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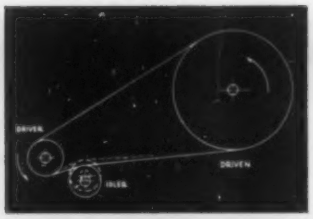
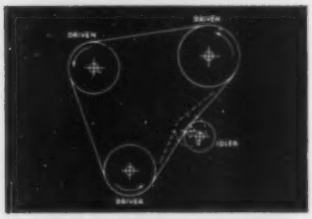
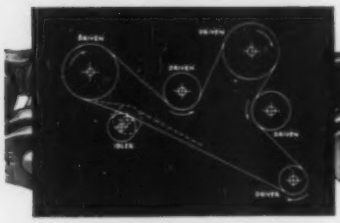
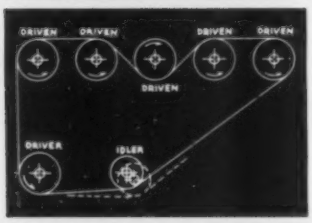
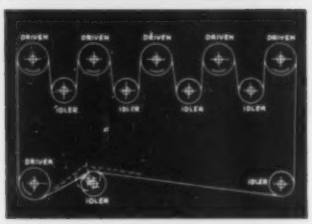
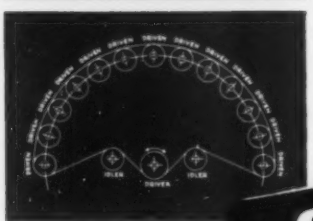
All types of ball and roller bearings — 4" inside diameter to 178" outside diameter . . . Taper Roller *Roller Thrust *Roller Radial *Needle Roller *Ball Radial *Ball Thrust Bearings.

K-581

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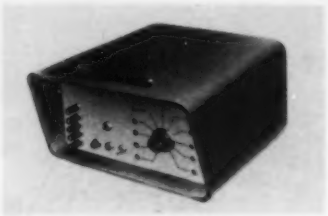
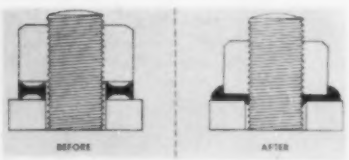


microsec. Lamp remains lit until reset by a manual reset button. Control unit measures 10 x 6 x 5 in. **Mu-tronics, Inc, 1514 S LaCienega Blvd, Los Angeles 35.**

Circle 11, Reader Service Card



Self-sealing lock washer . . .

is made of nylon. When nut is tightened, washer flows, its inner diameter gripping and sealing threads of nut and bolt, while outer diameter flows over outer edges of nut. Can be used repeatedly without loss of holding power. **Nylogrip Products, 449 Watertown St, Newton, Mass.**

Circle 12, Reader Service Card

Poppet valve . . .

has a stainless steel body and a neoprene O-ring seal. Operates on gas pressures from 0 to 150 psi and has effective orifice area of $\frac{\pi}{32}$ in. dia. Pushbutton head is said to be properly shaped and supported for operation by axial, angular or perpendicular forces. Body is threaded for $\frac{1}{8}$-27 NPT. **Hause Machines, Inc, Montpelier, Ohio.**

Circle 13, Reader Service Card

Subminiature limit stop . . .

is 0.625 x $1\frac{7}{32}$ in. and has torque rating of 18 in.-oz. Can be set to limit rotation of

(Continued on page 64)

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1145	3004	5050	5357

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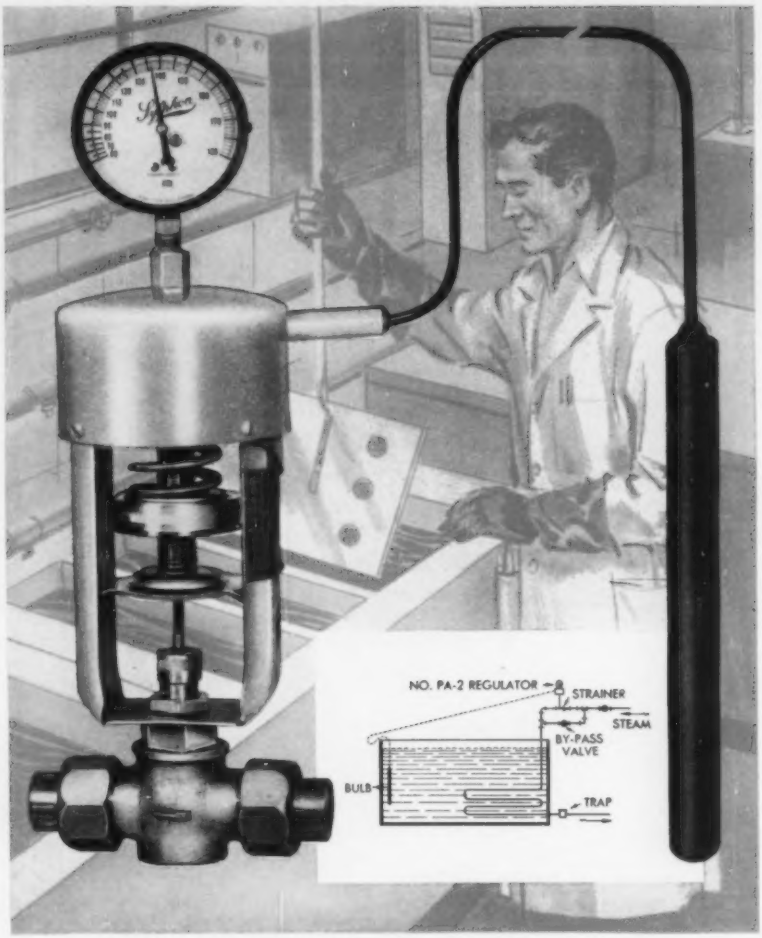

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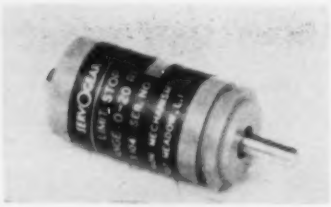
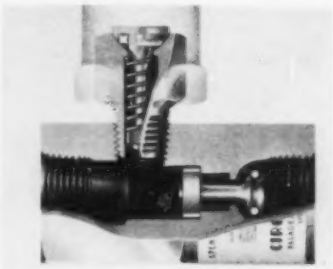
Mr. Controls® Robertshaw-Fulton CONTROLS COMPANY

FULTON SYLPHON DIVISION · Knoxville 1, Tenn.



miniature mechanisms to any angle from 0 to 20 revolutions by means of an external screw. **Precision Mechanisms Corp, 577 Newbridge Ave, E Meadow, N. Y.**

Circle 14, Reader Service Card



Gage protector . . .
can be actuated by over-pressure at any point from 5 to 2400 psi. Designed for gas systems and available for liquid systems. **Circle Seal Products Co, Inc, 2181 E Foothill Blvd, Pasadena, Calif.**

Circle 15, Reader Service Card

Miniature speed changers . . .
in over 400 ratios are offered for use in cameras, servomechanisms, oscillographs, chart drives and similar applications. Several types of attachable mounts are available. Input and output shafts run in double heavy-duty ball bearings. Countershafts run in special sintered iron and copper bearings that are self-lubricated. Hobbed, spur gears are 96-pitch and 20° pressure angle. Ratios from 1:1 to 5:1 handle to 16 in.-oz torque; ratios from 6:1 to 531441:1 handle to 24 in.-oz measured at low-speed shaft. Max power output at low-speed shaft is 0.025 hp. **Metron Instrument Co, 432 Lincoln St, Denver 3.**

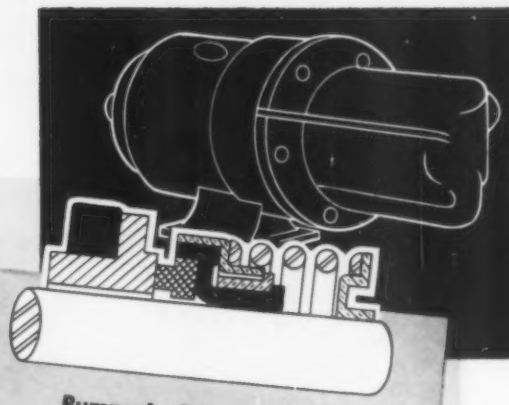
Circle 16, Reader Service Card

4-way pneumatic valves . . .
feature controlled expansion seal said to seal in all operating ranges from 28-in. vacuum to 150-psig and is characterized by low breakout friction. Valves utilize balanced, direct-operated spool which, with seals, allow use of small, low-amp solenoids as direct-operating force. Valve reverses position in less than 1 electrical cycle. Single and double solenoid-operated models and single or double pilot-operated

(Continued on page 68)

Machine Tools And Power Transmission Equipment

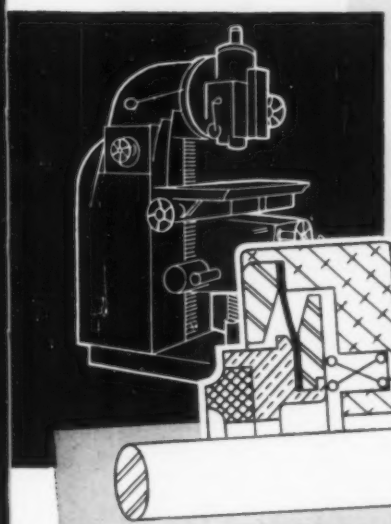
STYLE GU — A packaged sealing unit containing both rotating and stationary seal faces enclosed in metal housing. Stock sizes for shafts .250 through 4.000.



Pumps And Compressors

ROTO-FLEX — Rugged flexibility. Only 3 parts. Single or double units. Stock sizes for shafts .250 through 4.000.

STYLE RFO — A specially designed Roto-flex seal, for installation outside the stuffing box. Stock sizes for shafts .250 through 4.000.



Heavy Machine Tools

STYLE DPC — A high-speed, carbon-faced seal, for more compact installation in heavy industrial machinery. Stock sizes for shafts .250 through 4.000.

A Complete Line
GITS SHAFT SEALS
For Every Application

These modern, mechanical, face-type seals are carried in stock — to save you time and money. Write for detailed data.

GITS BROS. MFG. CO.

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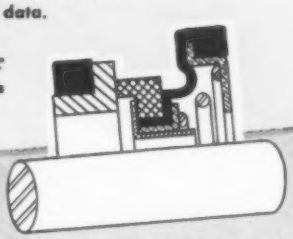
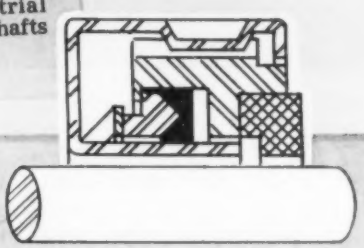


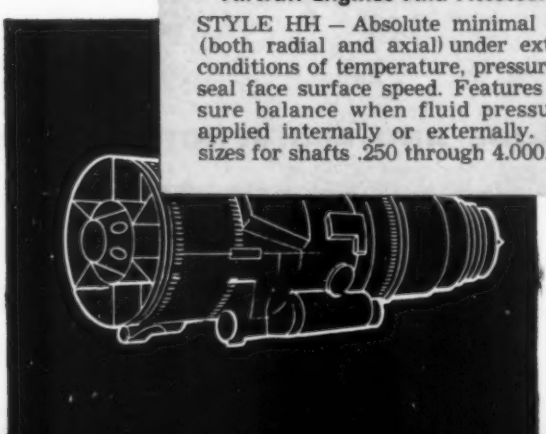
Household Appliances

STYLE SGU—A factory-assembled unit-type seal for the small-budget user. Stock sizes for shafts .250 through 1.000.



Aircraft Engines And Accessories

STYLE HH — Absolute minimal space (both radial and axial) under extreme conditions of temperature, pressure and seal face surface speed. Features pressure balance when fluid pressure is applied internally or externally. Stock sizes for shafts .250 through 4.000.



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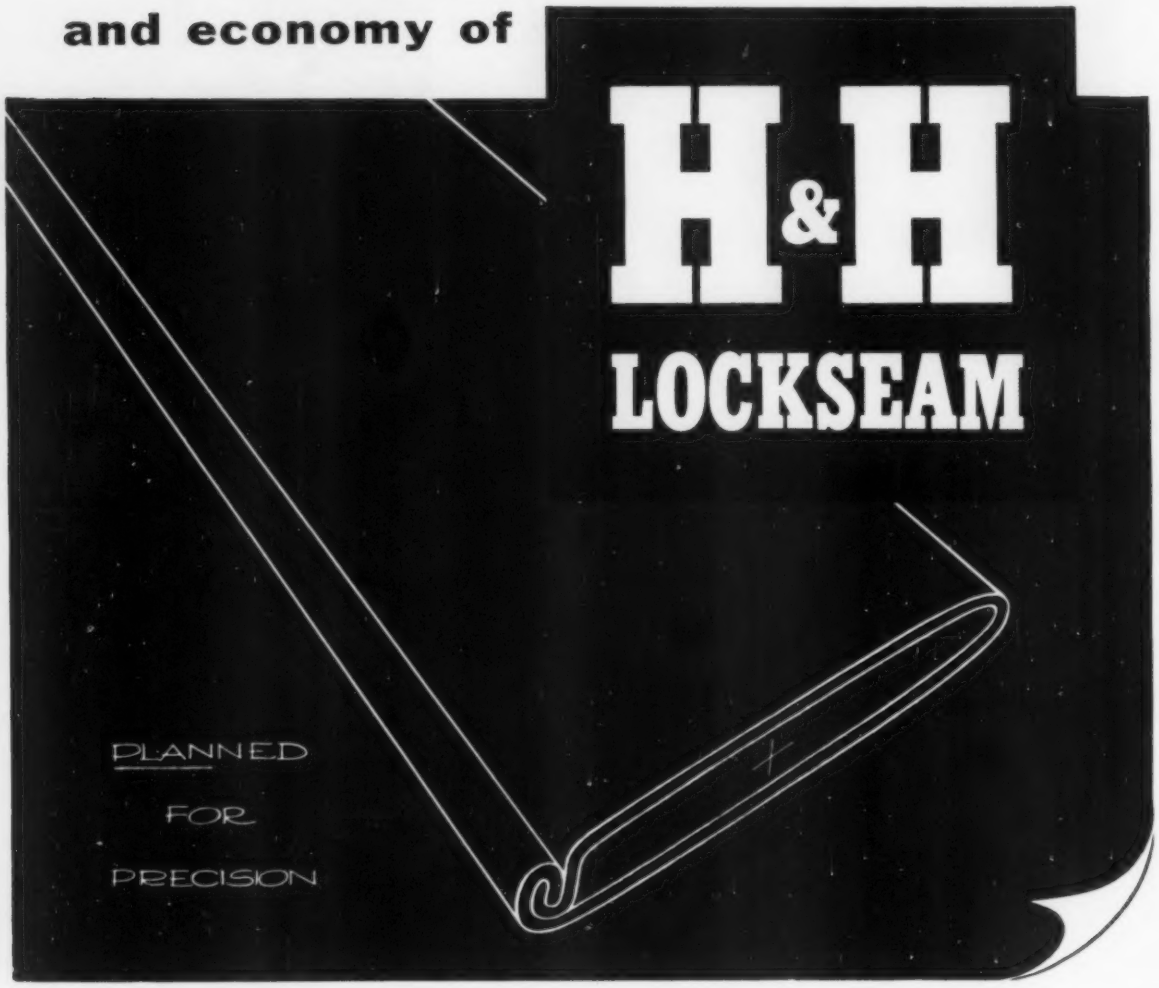
H&H LOCKSEAM



...YOU OWE IT TO YOURSELF to investigate this popular edge seam tubing without delay. It is used extensively by some of America's leading manufacturers of aircraft, jeeps, trucks, tractors, cars and stationary engines for most every heating and cooling purpose – from heat exchangers to radiator overflow tubes. Available in round and oval, solder coated on the outside or both sides, cut to customer specifications or in random lengths.

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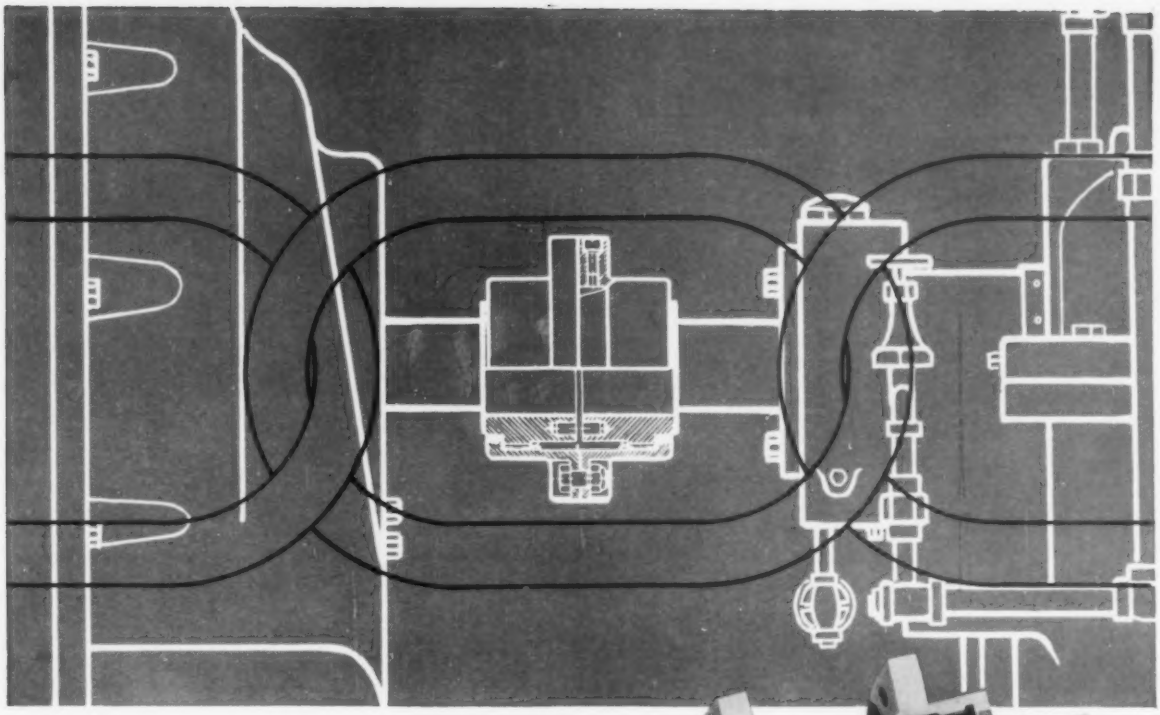
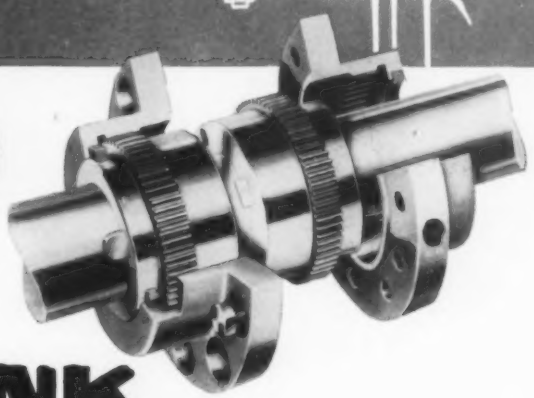
METALFLO LOCKSEAM COIL STRIP SEAMLESS TUBING TUBULAR PARTS



FOR WELL-DESIGNED EQUIPMENT...

SPECIFY THIS

POWER LINK



When a lot of time and effort have gone into the design of a piece of driven equipment, it makes sense to pick the power link carefully. Take a pump or compressor, for instance. No matter how well it is designed and built, for long service life and operating efficiency, it needs protection against strains due to misalignment.

Waldron gear couplings provide complete protection and positive, trouble-free drive because

They are strong . . . Hubs and cover sleeves for sizes 1¼A through 7A are machined from tough steel forgings. Hubs are keyed to the shafts. The two one-piece cover sleeves function as a single, rigid unit serving as a floating connecting link between the hubs. High strength of forgings makes possible a very compact coupling with low rotating inertia.

They are reliable . . . There are no flexible parts to bend or break and the coupling is dust, moisture, and oil tight. Patented Walflex seal is at the lowest possible diameter where centrifugal force is least. Clearance between teeth in hubs and sleeve is engineered so that an oil wedge always separates them, taking the wear.

They are available . . . Plenty of rough bore couplings, already assembled—on the shelf for *immediate* delivery. Finish bored standard couplings shipped to meet customers' schedules. We are geared up to give you realistic delivery on *any* type of couplings.

Ask for Catalog 57

JOHN **WALDRON** CORP.

A subsidiary Midland-Ross Corporation

NEW BRUNSWICK, NEW JERSEY

Representatives In Principal Cities
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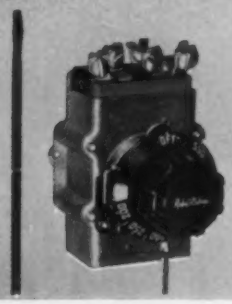
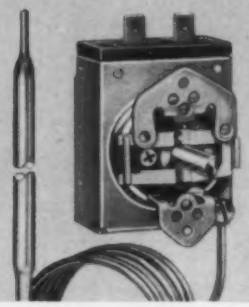
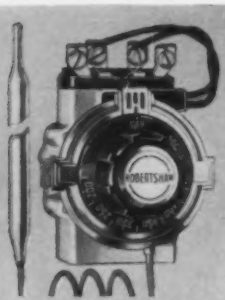
3-Phase Thermostat—available in various temperature ranges and dial markings. For use with 3-phase circuits on heavy duty electric ranges, sealing machines, etc. In operation, 2 phases keep cycling while the third phase is "on" during the entire operation. In "off" position all three phases are broken.



Domestic Appliance Controls for ranges, clothes dryers, air conditioners, room heaters, etc. Low in cost, compact and dependable, with quick response to extremely close temperature differentials. Silver contacts and stainless steel bellows for sustained accuracy.



Combination Fixed-Temperature Control and Switch for restaurant coffee warmers, egg washers, heaters for livestock water tanks and many other applications where a low cost control for maintaining a fixed temperature is required. Eliminates the problem of too much or too little heat.



High Temperature Controls of extreme accuracy and sensitivity for use with temperatures up to 800°F. Either direct or reverse acting types—single and double pole; single and double throw; single and double circuits; with and without limit switches. Corrosion-resistant tubing and bulb.

Unmatched for accurate, trouble-free performance

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Most Complete Line in the Industry. Robertshaw offers the widest variety of thermostats and controls for domestic and industrial use. Available for application in temperature ranges to 800°F.

Unmatched in Quality. Robertshaw's standards of material selection, manufacturing and quality control are second to none in the industry. The result—thermostats that give accurate, trouble-free performance under the most severe usage.

Engineering Assistance is Available. Robertshaw engineers will gladly assist you in application of the proper controls to your appliances or equipment. Laboratories are maintained at Youngwood, Pa.; Irwin, Pa.; Cleveland, Ohio; Long Beach, Calif.; and Anaheim, Calif. Remember, Robertshaw offers you more than 55 years of experience in control recommendations. Take advantage of it.

For information about your particular application write to:

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Robertshaw-Fulton CONTROLS COMPANY

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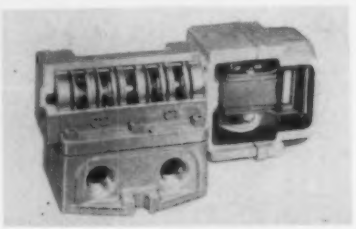

master valves are available in ¼, ⅜, ½ and ¾-in. pipe sizes. **Air Valves Co, 22729 Hoover Rd, Warren, Mich.**

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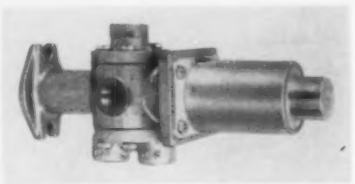

Dc solenoid valves . . .

are available for operation on 12, 24 or 125 v dc. They come in either standard or explosionproof housing. Valves are rated for oil and water pressures ranging from 0-250, 0-1500, and 0-3000 psi. Air valves are rated 0-250, 0-1000 and 0-1500 psi. Available in 4-way, 3-way, shutoff and diverter flow patterns. **Barksdale Valves, 5125 Alcoa Ave, Los Angeles 58.**

Circle 18, Reader Service Card

Silicone rubber kit . . .

consists of sample rolls of three new and three standard products. **Permacel, US Highway 1, New Brunswick, NJ.**

Circle 19, Reader Service Card

Tearproof drafting film . . .

withstands repeated erasures, folding and handling. Made from a Mylar base, film has tensile strength of 20,000 psi; tensile modulus of 550,000 psi and flex-life of 20,000 cycles. Said to be fungus-resistant, impervious to perspiration, water and soft drink spots. Available, too, with diazo and photo-type sensitized surfaces for print copies with the properties of the film. **Eugene Dietzgen Co, Dept P-10, 2425 N Sheffield Ave, Chicago 14.**

Circle 20, Reader Service Card

Portable vibration meter . . .

for use with vibration pickups measures velocity, displacement amplitude, acceleration. Transistor circuit is battery-powered Connection of transducer is necessary for readings. **Southwestern Industrial Electronics Co, 2831 Post Oak Rd, Houston.**

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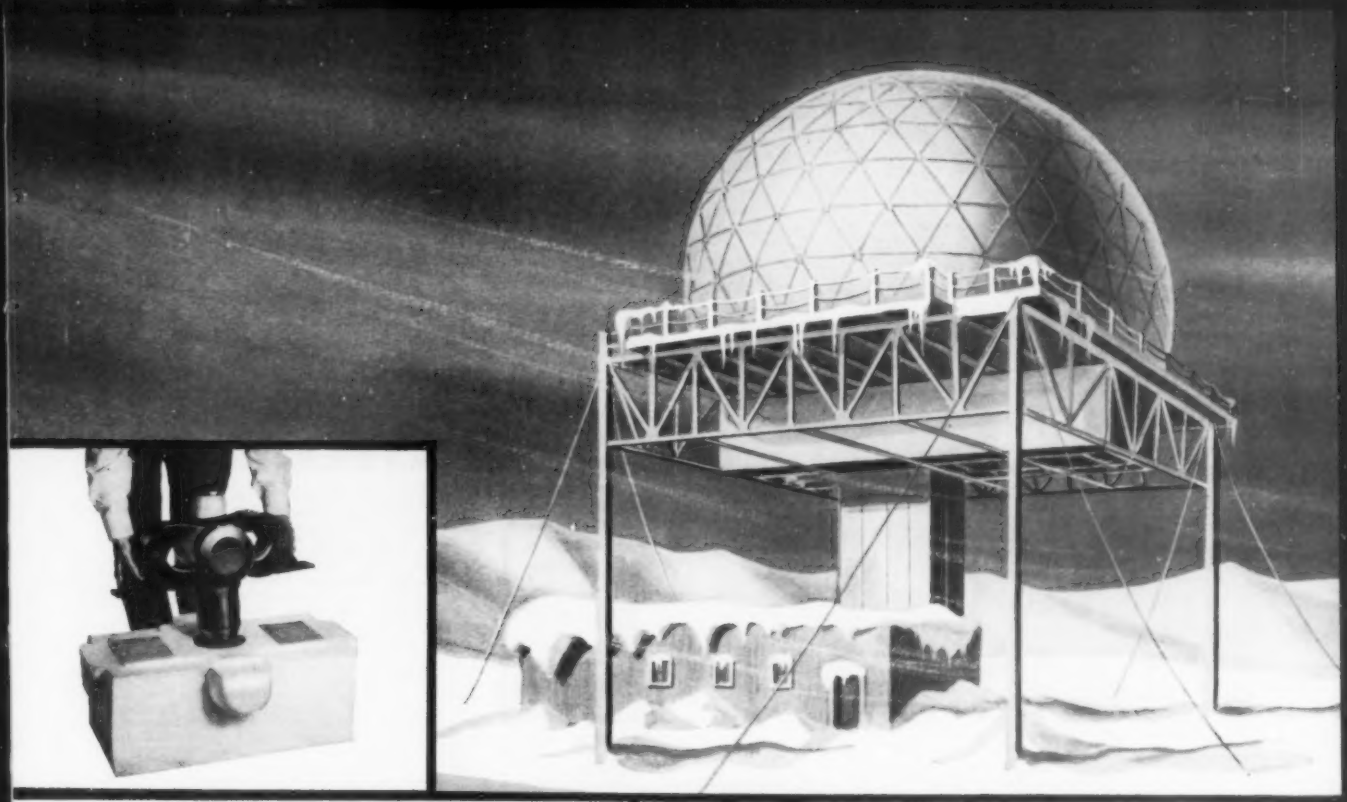
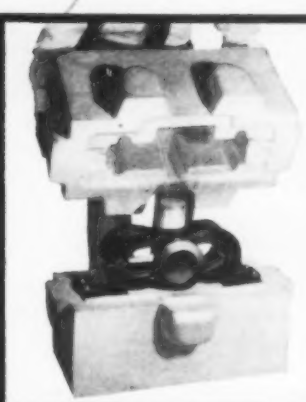


HERE'S HOW G.E. PROTECTS MAGNETRONS SHIPPED TO DEW LINE

Photos show how molded urethane package safeguards General Electric magnetron against shock and vibration in a simple corrugated carton—even at 50° below zero! Magnetron is bolted to aluminum plate bonded into bottom pad during molding. Projections molded at sides of pads provide air-space moisture barrier.

Costly conventional packaging would be 50% bulkier, 300% heavier! New package was developed by Standard Plastics, Inc. of Fogelsville, Pa.



for heavy duty packaging... lightweight URETHANE FOAMS

This very practical and economical package is one more example of urethane versatility.

Urethane foams ranging from flexible to rigid are well worth investigation wherever impact absorption, vibration isolation, comfort cushioning, thermal or acoustical insulation, or added structural rigidity is needed. Their unusual mechanical and dielectric properties are broadly controllable to meet your special requirements.

Being equally versatile in fabrication (molded, sprayed, poured to foam in place, or worked from slab stock) urethane foams frequently permit substantial production economies while they solve your difficult design problems.

If you have a potential use for urethane, perhaps our application laboratory can assist in its development. We produce NACCONATE® Diisocyanates, essential urethane components.

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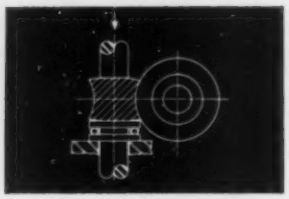
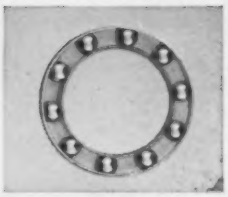
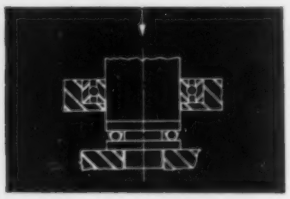
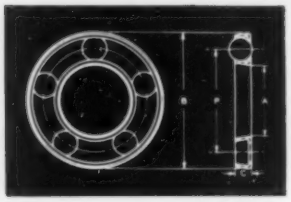
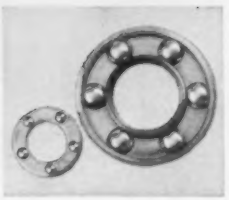
CIRCLE 131 READER SERVICE CARD











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carry the THRUST load

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Every design engineer should have this handy guide to thrust retainer applications, sizes and capacities. Your copy will be mailed promptly on request.

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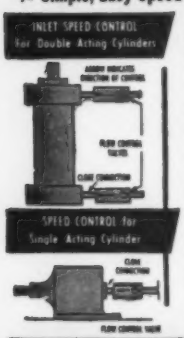
★ Compact Rugged Design
★ Simple, Easy Speed Selection ★ For Air, Oil or Water Applications



Pneu-Trol Speed Control Valves, are widely used in hundreds of control applications because they combine in a short, compact body, a tapered fine thread needle for extremely accurate air or oil flow control and a floating retro ball check, which permits full flow in the opposite direction. Retro ball floats in most sensitive position to its seat, requiring only a slight differential pressure to fully open or close it.

Needle design permits maximum flow capacity in the controlled direction. Metal to metal needle and ball seats insure long trouble-free service. Simple, practical "O" gland structure eliminates troublesome leaking. Valve bodies machined from hex brass or aluminum for 2000 psi working pressures; steel and stainless steel for 5000 psi. Made in 5 female pipe sizes—⅛" to ¾". ATTRACTIVE PRICES . . . IMMEDIATE DELIVERY.

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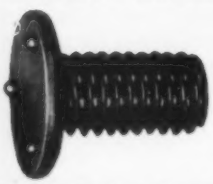
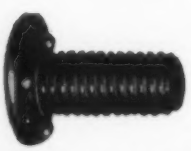
THE PRIMARY FASTENERS IN FASTENER ASSEMBLIES



GW SCREWS—Used where design requires a smooth unmarred surface and a fastener permanently fixed in place.

PD SCREWS—Used where it is desirable to place a threaded section on the edge of a sheet.

HH SCREWS — used where a single, button-type projection is required when welding to curved surfaces, to heavy sheet 3/32" or thicker, or to ends of rods.



HW SCREWS—Used where a self-locating through bolt is required to be fixed securely in place so that it will not turn and a flush surface is required for attaching mating parts.

Tread Size 6-32 to ⅜-16

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CIRCLE 132 READER SERVICE CARD

CIRCLE 134 READER SERVICE CARD

CATALOGS and BULLETINS

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ROLLER CHAINS—Book 2657, 154 pp, is page-indexed and describes selection, application, installation, lubrication, and maintenance of roller chains and sprockets for drives and conveyors. Data is included on chain casings, lubrication and maintenance, sprockets, leaf chains, flexible couplings and accompanying technical data. Table lists resistance of stainless and bronze to almost 400 corrosive agents. Link-Belt Co, Dept PR, Prudential Plaza, Chicago 1.

Circle 22, Reader Service Card

BUTT-WELDED TUBING—Handbook, 60 pp. Describes manufacture, uses of this tubing, and includes pertinent metallurgical, mechanical and engineering data. Pittsburgh Tube Co, 212 Wood St, Pittsburgh 22.

Circle 23, Reader Service Card

MACHINERY MOUNTINGS—Booklet, 23 pp. Discusses vibration control and isolation for all types of machinery. Includes case histories, cost reduction results, vibration studies and deflection curves. Dept WCH, Felters Co, 210 South St, Boston 11.

Circle 24, Reader Service Card

TITANIUM WELDING TECHNIQUES—Bulletin 6, 31 pp. Contains information on joint designs and engineering drawings, curves, tabular data on equipment, procedures, materials for fusion welding, inert-gas shielding, resistance welding, spot welding. Typical weldments are shown and means of determining weld quality described. Titanium Metals Corp of America, 233 Broadway, New York 7.

Circle 25, Reader Service Card

MAGNET WIRE—Catalog, 35 pp. Describes enamel, paper, cotton, vinyl, nylon, polyurethane, polyester-coated wires; and includes properties, thermal classifications. Electric Auto-Lite Co, Port Huron, Mich.

Circle 26, Reader Service Card

SEALED RELAYS—Bulletin GEA-6628, 24 pp. Offers information on hermetically sealed relays for military and general-purpose industiral applications. Circuit diagrams, coil data, and specifications for microminiature (including Type GS), subminiature, miniature, and high-speed relays are included. Ordering instructions also given. General Electric Co, Schenectady 5.

Circle 27, Reader Service Card

TOOL STEEL—Stock list 13. Contains data on water hardening, cold heading, oil hardening, air hardening, plastic mold, hot work steels, as well as brand-name chart of 13 different tool steel producers, a temperature conversion chart, tables of wire and sheet metal gages, and other useful engineering data. Uddenholm Co of America, Inc, 155 E 44th St, New York 17.

Circle 28, Reader Service Card

HEATERS AND HEATING DEVICES—Catalog GEC-10051, 52 pp. Has information on pipe heaters, thermostatically controlled immersion heaters, 1-in. water-immersion heaters, ratings and configurations of tubular heaters. Includes specifications, operating information and manufacturer's recommended list prices. General Electric Co, Schenectady 5.

Circle 29, Reader Service Card

LIGHT-STABLE STYRENE POLYMER—Technical Bulletin, 12 pp. Contains information on various testing techniques. Performance curves and pertinent property values are included. Dept SL, Plastics Div, Monsanto Chemical Co, Springfield, Mass.

Circle 30, Reader Service Card

CONTROL-DISPLAY LAYOUT—Booklet, 10 pp. Descriptive information, free samples and instructions on how to use special plastic laminated pictorials of standard controls and displays. Describes method for layout and provides information on performing maintenance analyses and schematic systems studies. Michelson-Peters Control Display Kits, 15537 Ventura Blvd, Encino, Calif.

Circle 31, Reader Service Card

SMALL SHADED-POLE MOTORS—Catalog U-1, 16 pp. Includes charts, diagrams and data on duty cycle, power sources, variations, braking, controls and operation. Discusses five motor types. Contains performance characteristics, ratings, construction, dimensions and typical applications. Barber-Colman Co, Rockford, Ill.

Circle 32, Reader Service Card

DESIGNING STEEL BELT CONVEYORS—Engineering guide, 8 pp. Contains nomographs, tables, line drawings and graphs to simplify calculation of dimensions, hp requirements, pulley di-

(Continued on page 73)

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Variable speed . . . high starting torque . . . reversibility . . . high output . . . you get them all in Heinze Universal Motors. Horsepower ratings are from 1/15 hp to 1/50 hp, with load speeds of 5000 to 7500 rpm. Normally designed for 115V AC/DC, CW, CCW or reversing. Other voltages are available. Internal or external brushes may be supplied. Type DL has die cast housing. Broad applications include sewing machines, business machines, movie projectors, electric organs, small hand tools.

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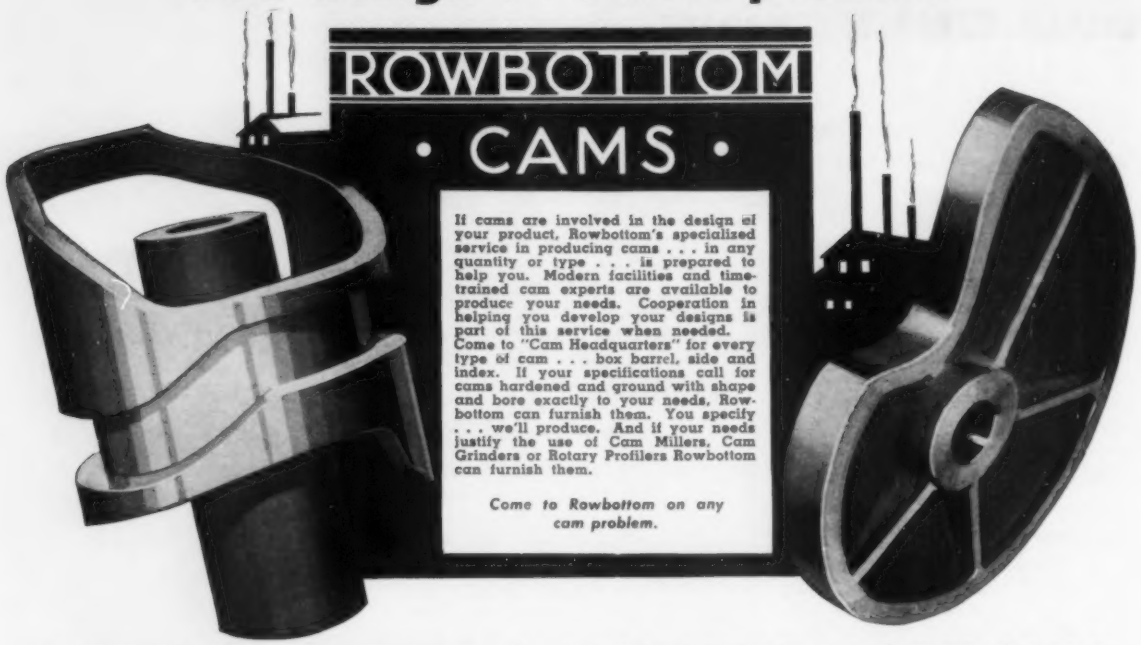
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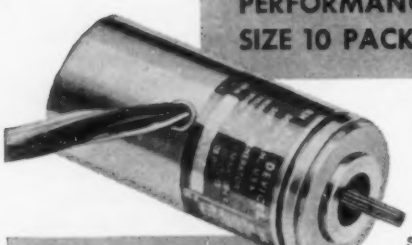

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ameters and idler roller spacing. Gives properties of carbon and stainless steel belts, methods of support, end joints, inclines, belt tension data. Sandvik Steel, Inc, 1702 Nevins Rd, Fair Lawn, NJ.

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CERTIFIED ALLOY STEELS—Booklet, 8 pp. Explains eight-point plan that alleviates uncertainties over mechanical properties and certificate of analysis and hardenability that accompanies shipments. Jos T Ryerson & Son, Inc, Box 8000-A, Chicago 80.

Circle 34, Reader Service Card

PIPE INSULATION—Folder WPN-2, 8 pp. Emphasizes advantages of lightweight glass fiber insulation for temperatures from subfreezing to 350 F. Gives physical properties, thermal conductivity, various types of factory-applied jackets, comparison of other insulation thicknesses required for equal performance, and dimensions. Includes guide to specs for application and finishing. With curves and drawings. LOF Glass Fibers Co, 1810 Madison Ave, Toledo 1, Ohio.

Circle 35, Reader Service Card

ALUMINUM RIGID CONDUIT—Booklet, 12 pp. Outlines mechanical and electrical advantages briefly and gives dimensions and weights of conduit, couplings and elbows. Various applications are illustrated and specific installation instructions are given. Aluminum Co of America, 1501 Alco Bldg, Pittsburgh 19.

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FHP MOTORS—Bulletin 1021-B, 8 pp. Describes and illustrates ac and dc Type N motors in standard ratings from 1/150 to $\frac{1}{6}$ hp at 1725 rpm. Includes construction details, motor dimensions. Bodine Electric Co, 2500 W Bradley Pl, Chicago 18.

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MIDGET VALVES AND FITTINGS—Catalog 658, 8 pp. Covers valves and fittings for 10,000 through 60,000 psi and for $\frac{1}{8}$ and $\frac{1}{4}$-in. tubing and $\frac{1}{8}$ and $\frac{1}{4}$-in. NPT connections. Diagrammed are 2- and 3-way midget valves. High Pressure Equipment Co, 1222 Linden Ave, Erie, Penna.

Circle 38, Reader Service Card

VARIABLE-SPEED DRIVE—Bulletin SB-183, 4 pp. Basic schematic illustrates principle of three-element unit that provides dc variable-speed drive from an ac network. Each element is illustrated. Optional features are listed. Marathon Electric Mfg Corp, Wausau, Wis.

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STEEL CONVEYOR PULLEYS—Catalog CV-1, 4 pp. Specs and price information on pulley line and also on interchangeable bushings and conveyor takeups. Information Div, Maurey Mfg Corp, 2915 S Wabash Ave, Chicago 16.

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X-Y PLOTTER—Bulletin AP-810, 4 pp. Describes and illustrates Model 1100E, which plots X vs Y and, with accessory equipment, acts as a function generator. Discusses features, gives technical specs and explains various components. Illustrated with photos and diagram. Electronic Associates, Inc, Dept of Technical Sales Literature, Long Branch, NJ.

Circle 41, Reader Service Card

ELECTRONIC AND MECHANICAL COMPONENTS—Bulletin ME-65810, 8 pp. Introduces new symbol and provides information on firm's four major divisions. Some plant facilities are illustrated. Model Engineering & Mfg, Inc, 50 Frederick St, Huntington, Ind.

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INTEGRAL PUMP-AND-MOTOR UNITS—Bulletin 31, 8 pp. Describes 192 combinations of pump and motor with capacities of 0.3 to 55 gpm. Presents pump and motor dimensions, construction, performance data, and illustrates several applications. Roper Hydraulics, Inc, 340 Blackhawk Park Ave, Rockford, Ill.

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HIGH-TEMPERATURE MATERIAL—Booklet, 8 pp. Discusses silicon nitride designed to operate up to and over 3000 F. Includes property data, test results, design considerations and applications. Haynes Stellite Co, Div of Union Carbide Corp, Kokomo, Ind.

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DUCTILE IRON—Folder, 6 pp. Summarizes significant engineering and design advantages. Mechanical properties, specifications and applications for various castings are tabulated. Hamilton Foundry & Machine Co, 1551 Lincoln Ave, Hamilton, Ohio.

Circle 45, Reader Service Card

KNITTED MESH—Brochure, 8 pp. Describes material, its properties and uses. Metal Textile Corp., 643 E. 1st Ave, Roselle, N. J.

Circle 46, Reader Service Card

SILICONE FLUIDS FOR MECHANICAL APPLICATIONS—Engineering guide 3-112, 8 pp, is a compilation of tables, graphs and figures, as well as property data, on silicone fluids and selection of most suitable medium. Typical applications show how silicone fluids are used to advantage in damping, springing, coupling and related mechanical applications. Dow Corning Corp, Midland, Mich.

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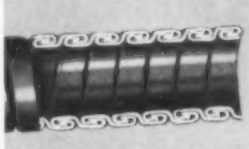

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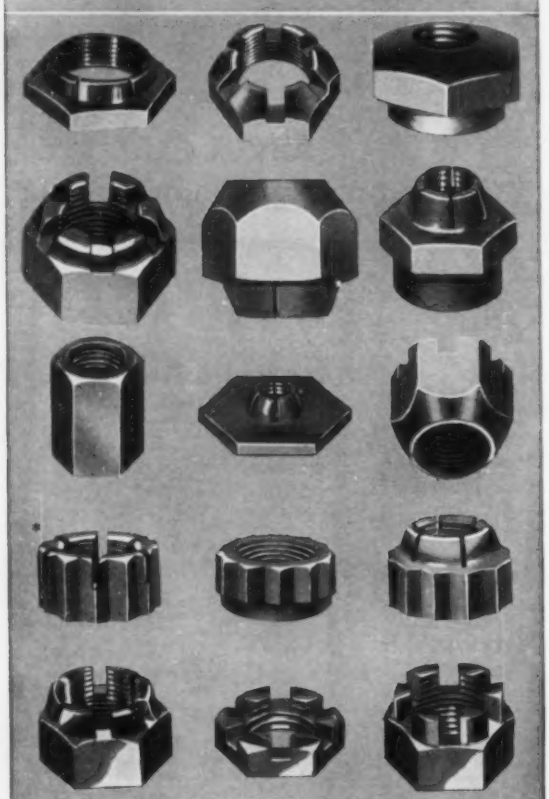

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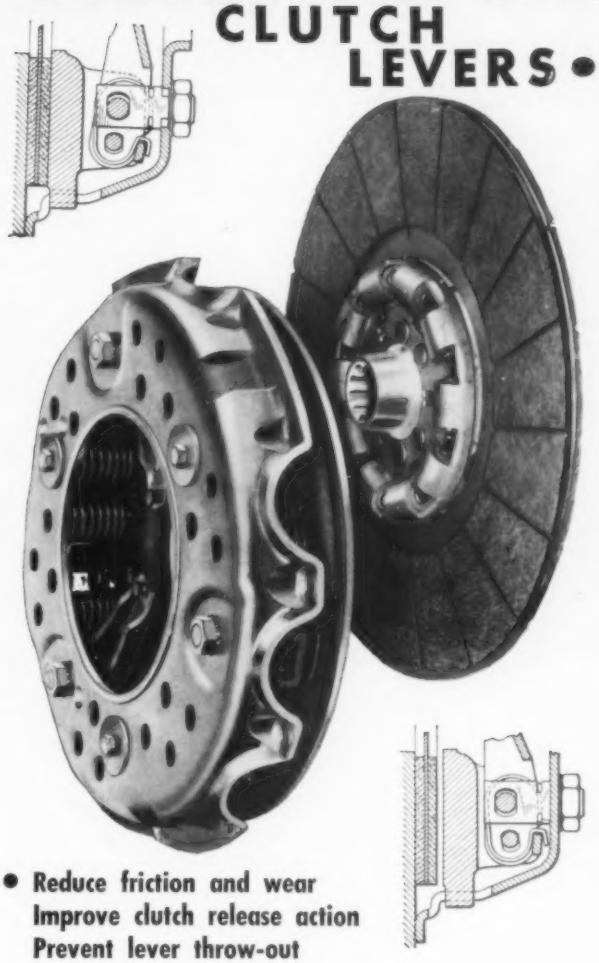

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*Item No.	PRODUCT

1	13	25	37	49	61	73	85	97	109	121	133	145	157	169	181	193	205	217	229	241	253	265	277
2	14	26	38	50	62	74	86	98	110	122	134	146	158	170	182	194	206	218	230	242	254	266	278
3	15	27	39	51	63	75	87	99	111	123	135	147	159	171	183	195	207	219	231	243	255	267	279
4	16	28	40	52	64	76	88	100	112	124	136	148	160	172	184	196	208	220	232	244	256	268	280
5	17	29	41	53	65	77	89	101	113	125	137	149	161	173	185	197	209	221	233	245	257	269	281
6	18	30	42	54	66	78	90	102	114	126	138	150	162	174	186	198	210	222	234	246	258	270	282
7	19	31	43	55	67	79	91	103	115	127	139	151	163	175	187	199	211	223	235	247	259	271	283
8	20	32	44	56	68	80	92	104	116	128	140	152	164	176	188	200	212	224	236	248	260	272	284
9	21	33	45	57	69	81	93	105	117	129	141	153	165	177	189	201	213	225	237	249	261	273	285
10	22	34	46	58	70	82	94	106	118	130	142	154	166	178	190	202	214	226	238	250	262	274	286
11	23	35	47	59	71	83	95	107	119	131	143	155	167	179	191	203	215	227	239	251	263	275	287
12	24	36	48	60	72	84	96	108	120	132	144	156	168	180	192	204	216	228	240	252	264	276	288

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SUBSCRIPTION

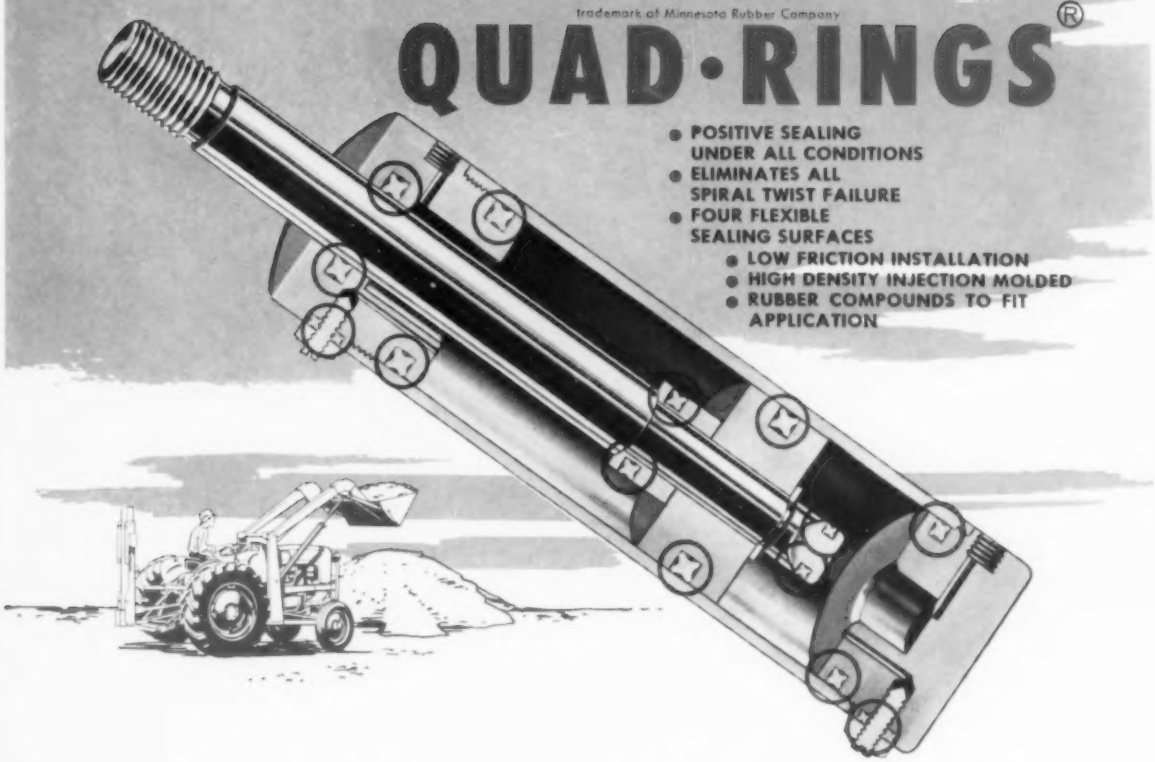
MINNESOTA MR RUBBER

FACTS for FILING on

trademark of Minnesota Rubber Company

QUAD·RINGS®

- POSITIVE SEALING UNDER ALL CONDITIONS
- ELIMINATES ALL SPIRAL TWIST FAILURE
- FOUR FLEXIBLE SEALING SURFACES
- LOW FRICTION INSTALLATION
- HIGH DENSITY INJECTION MOLDED
- RUBBER COMPOUNDS TO FIT APPLICATION



POSITIVE SEALING UNDER ALL CONDITIONS
The MR QUAD-RING gives superior sealing in reciprocating, rotary, and static applications at pressures ranging from 0 on up.

ELIMINATES ALL SPIRAL TWIST FAILURE—This costly cause of O-ring failure is eliminated because the relatively square cross-section of the QUAD-RING will not roll.

FOUR FLEXIBLE SEALING SURFACES—gives double the sealing effectiveness of the O-ring because of the exclusive seal design. It prevents leakage and requires less squeeze.

LOW FRICTION INSTALLATION—is made possible because of the exclusive quadrilateral design. This permits much higher rotary speeds and gives the seal much longer life.

HIGH DENSITY INJECTION MOLDED—All QUAD-RINGS are molded by MR's exclusive injection molding process to give an exceedingly dense product. There are no voids to cause seal failure.

RUBBER COMPOUNDS TO FIT APPLICATIONS
MR compounds are designed to give the best possible service, using basic polymers such as natural or synthetic rubber, silicone or any other that will perform best under the specific conditions.

FOR MORE INFORMATION AND COPY OF THE QUAD-RING APPLICATION AND INSTALLATION HANDBOOK . . .

FREE COVER TO BIND YOUR MR "FACTS FOR FILING" PAGES

WRITE MINNESOTA MR RUBBER NAPA

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3630 WOODDALE AVENUE
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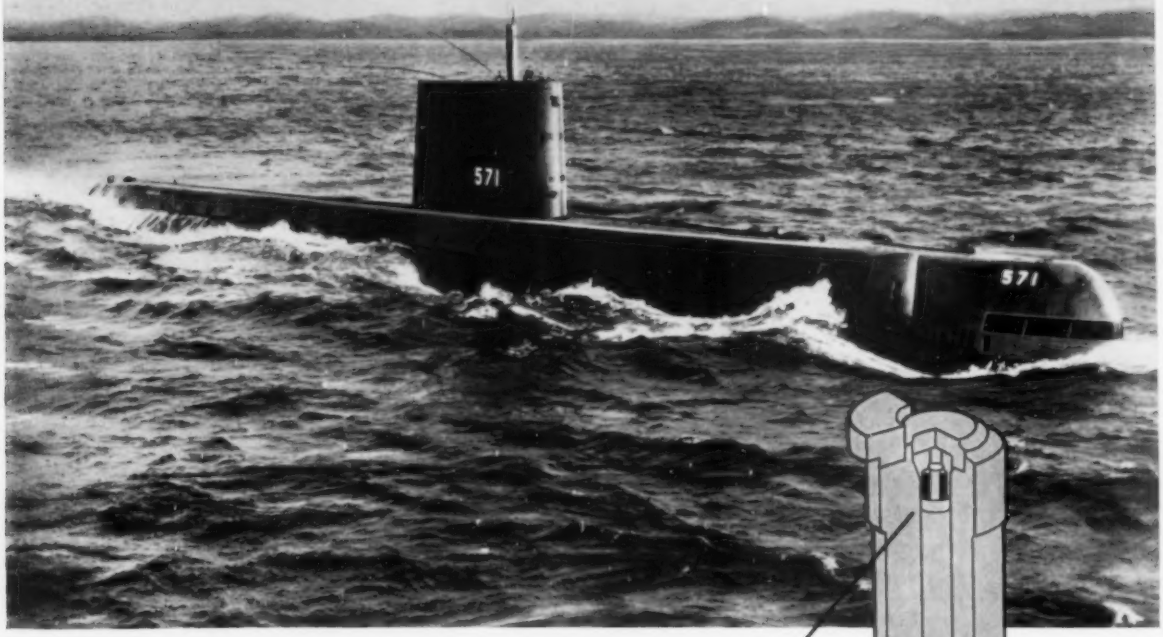
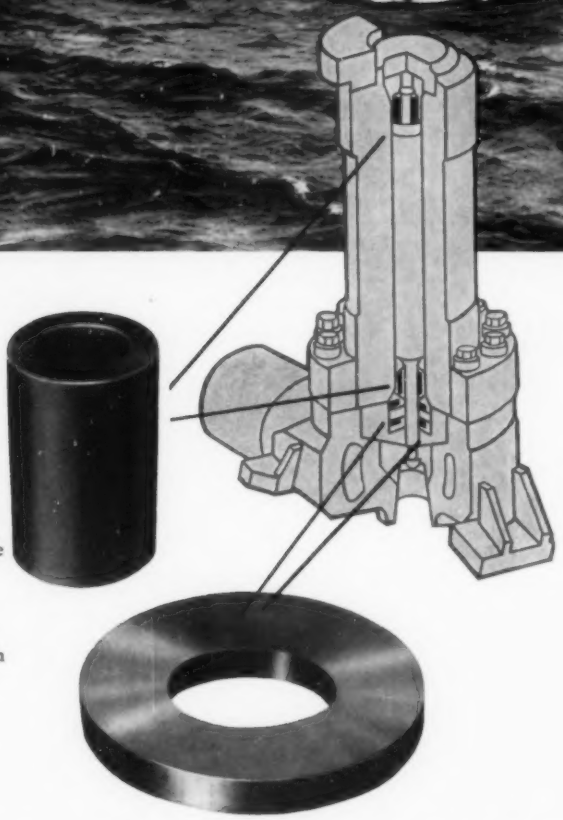
LUBRICATED ONLY BY RADIOACTIVE HOT WATER

GRAPHITAR® BEARINGS SUCCESSFULLY WITHSTAND 50,000 MILE TEST IN ATOMIC POWERED SUBMARINE U.S.S. NAUTILUS





Working closely with the Atomic Energy Commission, the Westinghouse Electric Corporation designed and built the power plant for the NAUTILUS, first atomic-powered submarine. The soundness of every engineering principle, every individual part—including the GRAPHITAR pump bearings—has now been proved by the more than 50,000 miles the submarine has steamed, approximately half was submerged. These Westinghouse-designed pumps are hermetically sealed within the integrated pump and drive motor. All leakage past the pump seal is contained within the flooded motor while the purely electrical elements are contained in "cans" to exclude the water.

The GRAPHITAR pump bearings in the power reactor of the Nautilus have withstood high speeds, extreme temperatures, and great pressures, and have come through this test-period with a perfect performance record . . . their only lubricant, radioactive hot water!

This same GRAPHITAR that has proved its ability to help harness the power of the atom is available for use in performing equally tough jobs in your product, too . . . why not get full information today.

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THE UNITED STATES GRAPHITE COMPANY

GRAPHITAR® CARBON-GRAPHITE • GRAMIX® POWDERED METAL PARTS • MEXICAN® GRAPHITE PRODUCTS • USG® BRUSHES

DIVISION OF THE WICKES CORPORATION, SAGINAW 1, MICHIGAN